THURSDAY, MARCH 22, 1894.

THEORY OF FUNCTIONS.

A Treatise on the Theory of Functions. By James Harkness, M.A., Associate Professor of Mathematics, Bryn Mawr College, Pa., and Frank Morley, M.A., Professor of Pure Mathematics in Haverford College, Pa. (London and New York: Macmillan and Co., 1893.)

IF evidence were wanted of the recent progress of the study of pure mathematics on English and American soil, none better could be furnished than the appearance on the two sides of the Atlantic, within a short interval, of two important works on the theory of functions of a complex variable. But a few years ago this great modern branch of mathematics was so little known to English-speaking mathematicians that scarcely a trace of its influence could be traced in their writings, and the majority of our text-books were disfigured by incompleteness, and not seldom by positive error arising from ignorance of its principles. Now the English reader has at his disposal two extensive works dealing with the fundamental principles of the theory from all the more important points of view; and also a very useful aid in Cathcart's valuable translation of Harnack's "Elements of the Differential and Integral Calculus." Probably nothing could serve better as an exorcist of the spirit of formalism which has oppressed the English school of mathematicians so heavily, in spite of all the great things that its leaders have done for the science, than the study of the theory of functions. In no other mathematical discipline is the fundamental unity of logic kept so constantly before the student; nowhere else in mathematics is it so clearly made evident that the manifold array of symbols is the clothing, and not the soul of mathematical thought; and nowhere else can we perceive so fully that progress is to be looked for mainly in strengthening our hold upon elementary conceptions, in continual refinement of definition and continual increase of stringency in inference, together with the necessary complement of this, viz. a continual widening of our power of imagining logical possibilities.[1] A single illustration of these general remarks may be cited here, viz. the important part now played in mathematics by the classification of the possible singularities of a function. Although as yet this classification has hardly proceeded beyond the first stage of distinguishing between what Weierstrass has called essential and non-essential singularities, yet the exceeding fruitfulness of the idea is very manifest in every part, not only of the theory itself, but of its applications. In this connection we may remark that anyone who is sceptical as to the value of function-theory, should compare the treatment of the theory of elliptic functions as given in chapter vii. of the treatise now before us, with the older method of dealing with the same subject. He will there find the theorems which used to be for many of us a mere savagery of riotous mathematical formulæ, sitting now clothed in their right minds—the cultured dependents of a few leading ideas.

[1] It is in this particular that the peculiar originality of Cauchy, Riemann, and Weierstrass, the three great leaders in the theory of functions, has been so conspicuous.

Our first impulse, after dipping here and there into the work of Messrs. Harkness and Morley, and recognising its substantial character, was to regret that so much learning and ability had been wasted in a field already covered by the admirable treatise of Forsyth. A more careful reading convinced us that this feeling was a mistake. The subject is wide enough to allow of two independent treatises; and the two works are independent so far as two mathematical works, each partly historical, dealing with the same subject, can be. Like Forsyth, Harkness and Morley are full of valuable references, not only to the great writers and the great memoirs on the subject, but also to the minor writers and to memoirs dealing with points of detail. So much is this the case, that we doubt whether in the matter of history and references the continental student has anything to equal, and certainly he has nothing to surpass, what the English student now possesses in Forsyth, combined with Harkness and Morley.

The more recent work does not, it is true, rival Forsyth in style and width of view. It is constructed more nearly on the model of a continental treatise, not reaching the airy elegance of a French work, but happily avoiding the intolerable prolixity and dulness of too many continental books, where a parade of generality not unfrequently engenders obscurity, or covers a poverty of fruitful ideas. It is inseparable from the nature of the subject that the unskilled reader should at times find passages that seem obscure. In such cases he will find it of great advantage to turn from Forsyth to Harkness and Morley, or from Harkness and Morley to Forsyth. The greater detail in some of the demonstrations in certain parts of the subject which characterises the treatise before us will often be a help to the reader who has run aground in Forsyth. A mere remark which constitutes a full demonstration to a mind properly prepared or naturally sufficiently nimble to receive it, often proves an enigma to another mind not so well "disposed," or, what is worse, is taken after the manner of the patient who, instead of taking his doctor's medicine, swallowed the prescription. If we might advise the beginner, we should say, first read Forsyth rapidly, possibly superficially with judicious omission, in order to get a good idea of the nature and aims of the theory; then proceed to work carefully through Harkness and Morley; and, finally, again read Forsyth carefully; so that the last impressions should be of the "poetry of the subject."

Chapter i. of Harkness and Morley's work is a very elegant and valuable geometric introduction to the subject, containing, besides the usual matter, a number of excellent graphical illustrations of the theory of invariants by means of Argand's diagram. Chapter ii. gives an account of the more recent refinements in the theory of functions of a real variable, in so far as such are necessary for the purpose in hand. In chapter iii. the theory of infinite series is dealt with in sufficient detail, and the reader is thus rapidly introduced to Weierstrass's theory of the analytic function, its continuation, its singular points and lacunary spaces. Chapter iv. deals specially with the algebraic function, its zeros, poles, and branch

points, the expansions which represent it in the neighbourhood of ordinary and singular points, its cycles, &c. Chapter v., on integration, introduces the fundamental theorems of Cauchy, with their applications to the establishment of the theorems of Weierstrass and Mittag-Leffler regarding the general expressions for functions with assigned singularities. In chapters vi. and ix. we have the substance of Riemann's theory, both direct and inverse. The account of the inverse theory consists largely of an exposition of Schwarz's solution of Dirichlet's problem, on which depends the proof of the existence of "functions of position" on a given Riemannian surface. The applications of the theory are amply illustrated in chapter vii., which contains an admirable sketch, already alluded to, of the Weierstrassian theory of doubly periodic functions; and in chapters viii. and x. on double theta-functions and Abelian integrals.

From this enumeration our mathematical readers will see that Messrs. Harkness and Morley have provided for them an ample and varied bill of fare; and we have no hesitation in saying that the feast is worthy of the bill. We would merely express, in conclusion, our desire to see this pair of authors soon abroad again in another of the many fields that still await the conscientious writer of English mathematical text-books. G. CH.

THE CONSTRUCTION OF DRUM ARMATURES AND COMMUTATORS.

Drum Armatures and Commutators. By F. M. Weymouth. (London: The *Electrician* Printing and Publishing Co., 1893.)

IN the preface to this book we are told that it is intended as "a useful guide or introduction to those who may ultimately wish to proceed with the mathematical treatment of the subjects," and further, that "the beginner will read these pages during the early period of his training, while he is studying his mathematics, and so may combine the two together at a later and more advanced stage." To such this work can be recommended, for the author has collected a good deal of information, which is well illustrated by woodcuts, showing how different makers have built up their armatures and commutators, thus giving the student a variety of experience n this direction.

In the first three chapters the drum armature is discussed from a general point of view. It is contrasted with that of Gramme, and the generation of electromotive force explained. The distinctive difference between "electromotive force" and "potential difference" might have been at this stage (p. 9) pointed out with greater clearness. For instance, in a direct current dynamo when working on open circuit the "electromotive force" of the machine and the "potential difference" at the brushes are the same in magnitude if no current flows through the armature. But when giving current to the external circuit between the brushes, a difference at once steps in, the "electromotive force" being greater than the "potential difference" by an amount represented by the current into the ohmic resistance of the armature.

In chapter iii. the winding of armatures for heavy currents is discussed generally; then follow some notes on balancing armatures properly.

With regard to an effect of current in the armature, it is stated on p. 30 that when "the field is bored concentric with the axis of the armature, Foucault currents arise principally, if not entirely, when the bars pass under the trailing horns of the pole-pieces, where the induction lines are particularly dense. By 'trailing' horn is meant the last horn of a pole-piece which the bars leave or recede from as they revolve." This statement is not sufficient. Take the case of a shunt-wound motor (of the ordinary type) when loaded and working with a negative lead. Here it is at the "trailing" horn that the induction per unit area of the polar-surface is *less* dense than at any other part of the surface.[1] It should also be impressed upon the beginner that it is the "loading" of generator or motor which brings about this disturbance.

Six chapters (iv.–ix.) on the details of drum armatures for heavy currents, specially with reference to the end-connections, follow. These have been carefully compiled, and it must be said that they give a good insight into the construction of drum armatures. In the first of this series of chapters the prevention of Foucault currents is dealt with. With regard to making the air-space longer near the horns in order to remove the *cause* of Foucault currents, a word could be added. In what is generally termed the "inverted horse-shoe" type of machine, so largely used at the present time, the pull upon the armature due to magnetism is in an upward direction, and with concentric fields outbalances the weight of the armature, thus causing a considerable pressure on the upper brasses of the bearings. When such a dynamo is direct-coupled to a steam-engine which works with a constant *downward* thrust, serious stresses are brought into play by these opposite forces acting at different points on the shaft. In such cases the widening of the air spaces near the two top horn pieces is usually resorted to, to relieve the pull on armature due to magnetism.

After describing the Edison "plate" end connection in detail, we come, in chapter vi., to the "evolute" end connection, which is described firstly in connection with bars cranked radially towards the shaft. Then follows a description of "evolutes," in which the cranked bar is dispensed with entirely. With regard to this latter, it is unfortunate that the author has not given details of the "Siemens" bar armature, which would have added to the value of the work. He of course recognises Von Hefner Alteneck as the inventor of evolute end-connections.

Eickemeyer's evolute wire-winding, Kapp's helical end-connection, and Swinburne's chord-winding are described in great detail. Chapter ix. treats of the Parson's helical outside end-winding, which is specially interesting on account of the enormous speed at which these armatures rotate. A description of Fritsche's winding is also given.

The subject of commutators claims chapters x.–xiii. In the introductory chapter (x.) "end play" in the bearings is mentioned as tending to more even wear of the surface of commutators. In this connection the author does not mention the "Halpin" gear, which has been introduced for the purpose of automatically moving the brushes longitudinally backward and forward on the

[1] See *Proceedings* of the Royal Society, vol. li. p. 49.

commutator to produce even wear; although with gauze brushes this would seem an unnecessary refinement—the wear of the commutator surface being in this case so small and even. With regard to "end play" a further word should be added. In the case of steam-dynamos, a fly-wheel is often placed between the dynamo and engine to steady the running. In such cases the fly-wheel becomes magnetised, and as a consequence the armature is pulled away from the engine, thus bringing into play a considerable pressure on the bearings. This is usually remedied by placing the armature core slightly out of symmetry (longitudinally) with regard to the magnet limbs.

The subject of insulation material for commutators is discussed—this being a point of great importance in armature building. Useful data under this head have been collected and tabulated.

Chapters xii. and xiii., on the *construction* of commutators and the manner of connecting the segments to the armature winding, are very good. Descriptions, amply illustrated by woodcuts, are given of the principal methods of construction adopted by makers, and the whole subject of commutators is well treated. On p. 116 a method is mentioned for preventing what is termed "slewing" of the segments caused by the washer going round with the nut (when not specially prevented) and taking the ends of the segments with it. This is a point in the construction of commutators worthy of attention.

In treating of the sparking at commutators, the author starts by giving an elementary theory of electric sparks, as introductory to the main subject; and after a description of what he terms "elementary planes through commutator and armature," he leads up to the elementary consideration of the brush itself.

A chapter is devoted to carbon brushes, and another to causes of sparking exterior to the machine. On the subject of armature reaction a good deal of information is given, and Sayer's system of winding, in which what are termed "commutator coils" are interwound with the main winding of the armature, is very fully described.

The book concludes with a chapter on armature defects, and a few practical hints on the taper of commutator segments.

E. WILSON.

BRITISH MOSSES.

Illustrated Guide to British Mosses. By H. G. Jameson, M.A. (Eastbourne: Published by the Author, 6, College Road.)

MR. JAMESON has produced a very useful treatise on British mosses, well calculated to aid the student of their systematic classification. The book consists of an introduction giving clear and valuable information on the structure of the mosses, with a useful section on the practical examination of specimens; a key to the genera; a short account of each genus, followed by a key to its species; and a series of 59 plates, containing over 2400 figures, all of which appear to be clear, and some of which are admirably drawn and lithographed. The figures are for the most part not those of the entire plant, but of those parts which are especially useful in distinguishing the species. As the book contains no description of each species, but of the genera only, the student must mainly rely on two things—on the key and on the plates. The result is to throw a great burthen on the key, which is framed on the familiar dichotomous arrangement, by which the student is continually presented with one or other of two courses, so that the success of his search depends on his taking the right one of the two alternatives before him at each successive step. A single false choice sends him off in the wrong direction, and all his labour is wasted. It follows that the choice put before the student at each step should be between two alternatives perfectly true, perfectly distinct, and, if possible, indubitable. Now, here Mr. Jameson seems to us sometimes to fail. We repeat that failure at a single point may be fatal to the student's course. For instance, when the student has got to No. 119 in the key, he finds himself in face of these alternatives:—

119 { Stem evidently pinnate or bipinnate, or with numerous divergent branches.
Stem not pinnate, not or sparingly branched.

Now, suppose our student has before him a specimen not pinnate, but with branches, and even with divergent branches, it may come under either of the two alternatives; and everything turns then on the antithesis of the two words "numerous" and "sparingly"; and neither of these words has any exact meaning—*i.e.* both of them are only expressive of degree—and no standard is given us, or could be given us, by which to tell whether the branches on a given stem are to be called numerous or sparing. Take again No. 186; the two alternatives before the student are thus stated:—

186 { Leaves curled up or merely flexuose when dry.
Leaves crisped and twisted when dry.

Now here the point to be settled, and a point on which the whole future of the hunt depends, may be whether a dry leaf is curled up or crisped and twisted; and surely the language used in the two cases does not, at least to us, state a clear antithesis. Again, there is to be found in many cases in these keys the use of adjectives in the comparative degree, which always seem to us bad in such a connection, because before you can find the plant to which it is applied you must find and make out the plant of which the positive degree is affirmed. Under "Fissidens," we are offered, for instance, these alternatives—"plant small" and "plant larger," "cells obscure" and "cells clearer." Again, we can well imagine a specimen in respect of which anyone would be puzzled whether to accept the description "leaves acute, yellowish"—not yellow, be it observed—or "leaves rather obtuse, nerve and border orange, cells smaller." Some of the characteristics given are open, also, to this objection, that they are certain to vary as to their obviousness, or even their accuracy, with the differences of the individuals, as regards age, nourishment, and habit. Linnæus was very right when he wrote, "Magnitudo species non distinguit. Magnitudo mutatur a loco, solo, climate: mutatur a copia alimenti in plantis, non minus quam in animalibus." But let us be fair to Mr. Jameson: he is not a sinner in these respects above many others who have gone before him, and have worried generations of students by the want of precision in the alternatives which they present to his choice. In one respect his

attempt is very laudable. Knowing how often mosses are found without fructification, he has endeavoured to rely upon characteristics afforded by the barren plant, and not upon those derived from the inflorescence or the capsule. Whether so important a part of the structure as the reproductive system can be safely neglected by the systematist, seems to us at least doubtful. One has heard the story of the man who boldly asserted that the peristomes of the mosses were created different in order to enable botanists to distinguish the species. That may be rash teleology, and certainly Mr. Jameson has not adopted it.

As the book is intended for beginners, we think that a glos sary should have been given.

E. F.

OUR BOOK SHELF.

Report of Observations of Injurious Insects and Common Farm Pests, during the Year 1893, *with Methods of Prevention and Remedy.* By Eleanor A. Ormerod, F.R.Met.Soc., &c. Seventeenth Report. (London: Simpkin, Marshall, Hamilton, Kent and Co., Ltd.).

ALTHOUGH the indefatigable Miss Ormero d, our principal English agricultural entomologist, has lately retired from the post which she has so long and so worthily occupied in connection with the Royal Agricultural Society, we are pleased to see that she has by no means relaxed her exertions in the cause, but has again brought out her usual annual volume, which will bear comparison with any of those which have preceded it, in the interest and value of its contents.

The year 1893 was remarkable for the great drought, which though it affected both vegetation and insect-life less than might have been expected, was necessarily favourable to the increase of some species, and injurious to others. The most noticeable feature was undoubtedly the unusual abundance of wasps over almost the whole of Great Britain and the adjoining countries; and thirty pages of Miss Ormerod's report are devoted to wasps alone. The remainder of this report treats of various insects infesting apple, bean, corn and grass, gooseberry, hop, mangold, mustard, pear, strawberry, tomato and cucumber, turnip and willow; and to the occurrence of locusts and mites (*Phytoptidæ*), not attached to particular plants. Most of the species noticed are freely illustrated in their various stages, so that there ought to be no difficulty about their identification, even by persons ignorant of entomology. Particular attention is given, as usual, to the best means of prevention and cure applicable to each case.

Fortunately the climate of England is less suited to the excessive multiplication of many insect pests which are highly destructive on the Continent and in America; and we are glad to notice that Miss Ormerod does not consider that the Hessian Fly, about which so much anxiety was felt a few years ago, is ever likely to become very destructive with us. Miss Ormerod also prints a letter from M. Schöyen, announcing the introduction of this insect into Norway; another instance of the impossibility of preventing insect pests being carried by the constant international traffic from country to country, where they establish themselves if the climate and conditions are favourable, but if not, they soon die out, or linger on in too small numbers to be really injurious.

The introduction of locusts into England in brocoli from South Europe, and (dead) in large quantities among hay from Buenos Ayres, is likewise worthy of notice.

Mustard beetles, and others of the more familiar farm and garden pests, still continue to require and to receive a considerable amount of attention.

In conclusion, we may express our hope that Miss Ormerod may long be spared to issue many more of her useful annual contributions to agricultural entomology.

W. F. K.

On the Definitions of the Trigonometric Functions. By A. Macfarlane. (Boston: J. S. Cushing and Co.)

DR. MACFARLANE has already written on space-analysis. The previous papers were on the principles of the algebra of physics, the imaginary of algebra, and the fundamental theorems of analysis generalised for space. The pamphlet before us was read before the Mathematical Congress at Chicago, August 22, 1893.

In the first of the above-cited papers the author introduced a trigonometric notation. This has been discussed by Mr. Heaviside in the *Electrician* (December 9, 1892). Dr. Macfarlane, by way of rejoinder, remarks: "I believe that this paper will show that trigonometry is not an application of space-analysis, but an element of it; and that the ideas of this element are of the greatest importance in developing the higher elements of the analysis." Our readers may remember that the notation was also discussed by Prof. Alfred Lodge (NATURE, November 3, 1892). To this our author replies: "I consider that the notation is a matter not of secondary, but of paramount importance. If the notation is arbitrary, it gives us no help in the further development of analysis; if on the other hand it is systematic and logically connected with the existing notation of analysis, it points the way to more general principles and results. I believe that this paper will show that my notation is systematic and logical." The pamphlet occupies 49 pages, and there are some other passages like those we have excerpted; so there is likely to be a pretty fight, of which our readers will soon hear more, if they do not take part in the strife. The pamphlet will repay perusal.

Key to Mr. J. B. Lock's Shilling Arithmetic. By Henry Carr, B.A. (London: Macmillan and Co., 1894.)

IN the worked-out results which we have now before us, Mr. Carr has not restricted himself to giving the mere answers, but has inserted in all cases the steps by which they are reached. This, especially for beginners, will be found of great service, and by judicious use will certainly lighten the teacher's task. We have selected many of the more advanced examples here and there, and worked them out as a test of the accuracy of the results given, and have found no mistakes. Others, perhaps, may not be so fortunate, but all necessary care seems to have been taken to give the right answers. All who use Mr. Lock's shilling book will find it of great assistance.

LETTERS TO THE EDITOR.

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The Thermal Expansion of Diamond.

IN view of the interest at present aroused by M. Moissan's successful experiments upon the artificial production of diamond, I venture to recount the results of some observations upon the thermal expansion of diamond, which, I think, are suggestive in connection with the particular manner in which M. Moissan has achieved success. M. Moissan has shown that the added condition of high pressure has rendered a method previously unsuccessful now for the first time successful.

Minute particulars being out of place here, I may briefly say

that the measurements given below were obtained by projecting, by aid of a 1" objective, the image of a diamond, which was rather less than 2 mm. in extreme length, into a camera, so that it was enlarged upon the screen to 11 c.m. across. Two micrometer eye-pieces with movable wires were directed upon opposite corners of the image, the diamond being manipulated in the field of the object-glass till these corners were in sharp focus. A movement of the wires of the reading microscopes by one division of the head of the micrometer in following the expansion of the image corresponded to a diametral enlargement of this latter by 0·0005 c.m., but owing to imperfect focus of the image no more than 0·001 could be accurately determined. If the coefficient of expansion of the substance were 0·00001 (that of platinum, about) the expansion of the image, due to 10° C. change of temperature, is just determinable. It will therefore be understood that over a wide range of temperature considerable certainty in the readings could be secured.

The heating was effected by radiation from a platinum ribbon folded in such a manner that the substance under observation occupied the central point of a narrow platinum tube. The ribbon was heated by a current. A beam of light from a very small sphere—2 mm. in diameter—of incandescent lime (heated in an oxyhydrogen flame) entered the tubular oven from the back. The adjustment of this beam greatly decided the sharpness of the projected image. Temperatures were determined

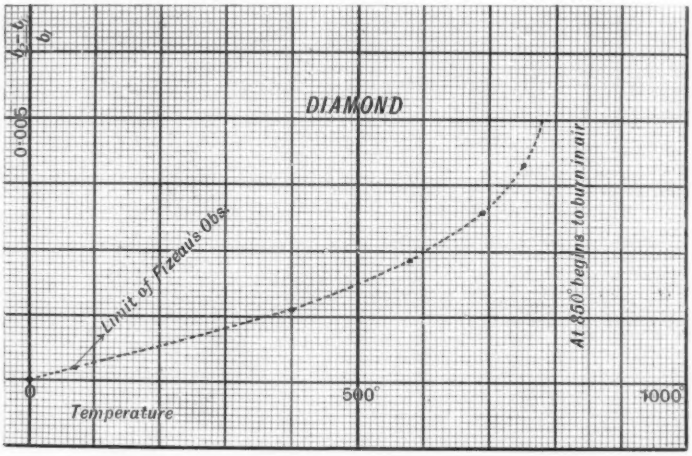

FIG. 1.

by melting substances of known melting-points in the oven, and reading the corresponding currents. Thus a curve of galvanometer readings plotted against temperature was obtained for subsequent use.

The results of the observations were four well-fixed points which give a curve (Fig. 1) seemingly tangential to Fizeau's results at low temperatures, but which curls up rapidly at about 750° C. At a temperature of 850°, and indeed below this, observations were stopped by the "efflorescence" upon the surface of the diamond of flaky particles which wriggled and twisted in a peculiar manner, finally disappearing. Once started, the "combustion" continued till the temperature of the oven was lowered to 712°. Cooling the oven, I subsequently photographed one face of the diamond. The picture obtained shows the face with a lamellar appearance, which was produced entirely by the heating, as at starting the faces were smoothly curved. Such an appearance is occasionally observed upon specimens of diamond. This photograph, as well as the curve of expansion, were shown at the *soirée* of the Royal Society in June 1892. The apparatus used was also shown in operation as applied to a minute globule of a melted basalt.

The sudden increase in volume or swelling-up of the diamond at high temperatures, suggests that the diamond is a form of carbon which has been subjected to high pressure when crystallising. Such changes we may expect to be reversible, and it is supposable that equilibrium at the higher density is only preserved by crystalline forces which will require to be brought into play by external conditions of pressure. It is probable that this is therefore an essential condition of success in its artificial production. It is perhaps of little interest to add that this reasoning gave rise to experiments—as I had leisure for them—which I only laid aside finally upon hearing of M. Moissan's success. I did not seek the aid of solution in a metal, but used an apparatus to compress graphite, as well as carbon prepared from sugar, between iron plates kept at a red heat, and urged together by the alternate heating and cooling of the bars of an iron yoke.

I am not without hope that the use of high pressure at a high temperature may ultimately prove sufficient—without resort to solution in a metal—to produce diamond. If the presence of a certain minute quantity of the carbide of a metal is essential, of course it will fail. It is difficult to imagine, however, that it should be essential. J. JOLY.

Trinity College, Dublin, March 5.

The North-East Wind.

PROF. BONNEY, in his "Story of our Planet," explains the prevalence of east winds at this season as being due to the low winter temperature of eastern Europe compared with the Atlantic coasts. If this explanation be the true one, we should expect the phenomenon to occur in December and January. My impression is, although I have no accurate statistics, that east winds do not prevail in those months in our climate. Further, we should expect, crossing the Atlantic in winter, to find for the same reason west winds prevailing off the American coasts. If this is not found to be the case, I would suggest the following as, if not the cause, at all events one of the causes, of the phenomenon in question.

The difference of temperature between the northern Arctic regions and the tropics, to which, combined with the earth's rotation, the north-east trade wind is supposed to be due, is necessarily greater in the spring months, February to June, than on the average of the year. Because in the Arctic regions, little or no heat being received directly from the sun between the autumnal and the vernal equinox, the maximum of cold should be attained in March or from February to April. In low latitudes these months are by no means the coldest. It is reasonable to expect that when this difference of temperature becomes accentuated, and the gradients, so to speak, steeper, the north-east winds which are due to it should become prevalent in higher latitudes than those to which the trade winds proper are usually confined. S. H. BURBURY.

The Suspension of Foreign Bodies from Spiders' Webs.

THE following instance of the use of a stone by a spider as ballast for its web is interesting.

A web was noticed stretched between two trees at a distance of about ten feet from one another. From it hung a thread about two feet long, and attached to its lower end was a small pebble about the size of a pea, the stone hanging free about four feet from the ground. The stone had evidently been made use of in this special manner by the spider for the definite purpose either of keeping the web taut, or as ballast to give it stability against the wind, for on lifting the stone to remove the pressure, it was observed that the web became limp and slack, and was stirred out of position by the least breath of air.

This was noticed by a score or so of members of the German "Turnverein" here, in the garden of whose premises the occurrence took place. R. PHILIPP.

Buenos Ayres, January 24.

THE FALLS OF NIAGARA AND ITS WATER-POWER.

TO render the vast energy of the Niagara Falls available for use in the industrial world has been the dream of many an enterprising spirit who has watched the immense volume of water plunging over the precipice, only to expend its energy in transforming itself (or its equivalent) into an invisible vapour, to be carried by the winds over to the lakes supplying the Falls, and pass through the same cycle again. But till quite recently little has been attempted. For many years past a few mills on the eastern cliff of the Niagara Gorge, below the Falls, have used a certain amount of the power, now aggregating about 6000 horse-power, by conducting water from the river above the Falls through a canal, and using it to drive turbines placed so as to benefit from only 90 to 100 feet or less of the total fall available, the water discharging down the side of the gorge after it has done its work. In this way it may be said that a start has been made, but it is only within the last few years that the utilisation of the power has been undertaken in a bold spirit, and this has become possible by the recent developments in electrical science, which enable power to be transmitted to a distance economically on a commercial basis.

To ensure success the enterprise had to be taken up on an extensive scale by a powerful company. Such a company is the Niagara Falls Power Company, who have been granted franchises for the utilisation of some of the water-power available. The company owns lands covering an area of 1500 acres on the "American" side, and extending along the upper river front for over two miles, on which they propose to develop a large manufacturing centre, but one of an entirely new order—one without the abominations of smoke and concomitant dirt, now so intimately associated with centres of the kind. An allied company has built a whole village on the lands of the Power Company; another has constructed railways to place the various factories in communication with the main lines of railway in the immediate neighbourhood; and others, again, have been formed to deal with the distribution of the power to all the cities and towns coming within the sphere of operations—a rather elastic term when dealing with high pressure electrical distribution. But although it is now more than three years since the Cataract Construction Company—the company formed for carrying out the engineering portion of the immense scheme projected by the Niagara Falls Power Company—commenced their operations, many in this country seem to be quite unaware that a great portion of their work has been already accomplished and the rest is in an advanced state, and of the manner in which the power is to be rendered available for industrial purposes. It is thought that a short description of the works, soon to be in operation, may not be without interest to the readers of NATURE.

That the Niagara Falls are peculiarly well suited to an undertaking of the kind now entered upon is well known. Situated in a comparatively narrow river, connecting Lakes Erie and Ontario, and supplied from a vast collecting ground, draining into the huge North American lakes forming the centre—Lake Superior, Lake Michigan, Lake Huron, and Lake Erie—the whole having an area of above 300,000 square miles, or nearly three times the area of Great Britain and Ireland combined, it might be expected that the discharge over the Falls would vary but slightly in volume or height. And such is the case. An estimated quantity of 265,000 cubic feet is precipitated over the Falls each second of time, with but slight variations, all the year round, in winter and summer, whether the river be laden with ice or the foot of the Falls appear choked with frozen spray, and in periods of drought or flood. The ordinary variations in level are not more than 1 foot above or 5 feet below the Falls, wind in general having the greatest effect on the level of the river. "The greatest authenticated changes of level," says Prof. W. C. Unwin, "below the Falls, due to ice-blocks in the river and other causes, amount to only 13½ feet rise above mean level and 9 feet fall below it." The drop at the Falls being about 160 feet, or, with the rapids above and immediately below the Falls, 214 feet, within a distance of a mile or a mile and a quarter, it will be seen that the above variations are unimportant; and, in addition, the actual fall to be used for the turbines will be 140 feet. Further than the above, the level character of the land on the "American" side, adapted for the cutting of canals and erection of factories; the right-angular relative position of the upper and lower

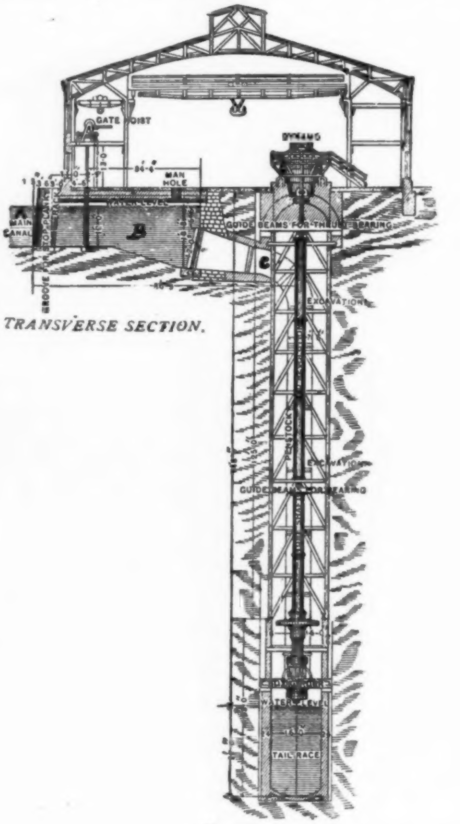

FIG. 1.

rivers, facilitating the construction of tunnels or tail-races for the disposal of the discharge water from the turbines; and, finally, the abundant means of communication, for the transport of raw materials and manufactured goods, with distant parts, existing in the three or four great lines of railway and the huge chain of navigable lakes in connection with the upper river; all point to the neighbourhood as being one particularly well adapted to the requirements of a power centre for industrial works of the character of that now being formed.

The hydraulic part of the works will be seen, on reference to Fig. 1, to consist broadly of a canal, a wheel-pit with its turbines, and a tunnel or tail-race. The canal, A, opens out from the upper river, about 1½ miles above the American Falls, that is, on the north or "American"

side, and extends in a north-easterly direction for 1500 feet, with a width of 350 feet, and a depth of 12 feet. At the end of this canal, on the north-west side, are sluice-gates controlling the flow of the water into side passages or head-races, B, which conduct the water to the pen-stocks, C, which guide it from the top of the wheel-pit to the turbines at the bottom. Fig. 2 shows the main canal in course of construction. In the background is seen the Upper Niagara River, flowing from left to right; and in the foreground appear two entrances to one of the head-races. The wheel-pit is nearly 200 feet deep, stone walled, and of sufficient length at present to accommodate three turbines, each of 5000 horse-power, and their penstocks. This will be extended as the demand for power increases. The turbines, which have been made by the I. P. Morris Company, of Philadelphia, from designs by Messrs. Faesch and Piccard, Geneva, Switzerland, are double and of the outward flow shortly to be available, in the continuity of the supply. It is approximately 19 feet wide, and 21 feet high. It is in section in the form of a horse-shoe, and has a mean grade of about 7 per 1000, and is perfectly straight in a vertical plane. Its length is 7000 feet, or over 1¼ miles. Four courses of hard brick set in cement line the tunnel throughout, the invert being paved with that of the hardest nature—vitrified brick—to resist the wearing action of the stream with its sand and other materials borne along by it. At the mouth of the tunnel the invert and sides are lined with steel plates forming a wave curve, the last few hundred feet sloping more than elsewhere, bringing the lower part of the mouth a few feet under the mean water-level. In this way the water of the river forms a cushion against which the discharge from the tunnel impinges. In Fig. 3 is seen, under the left-hand end of the suspension bridge, the incomplete mouth of the tunnel. In the distance are the American

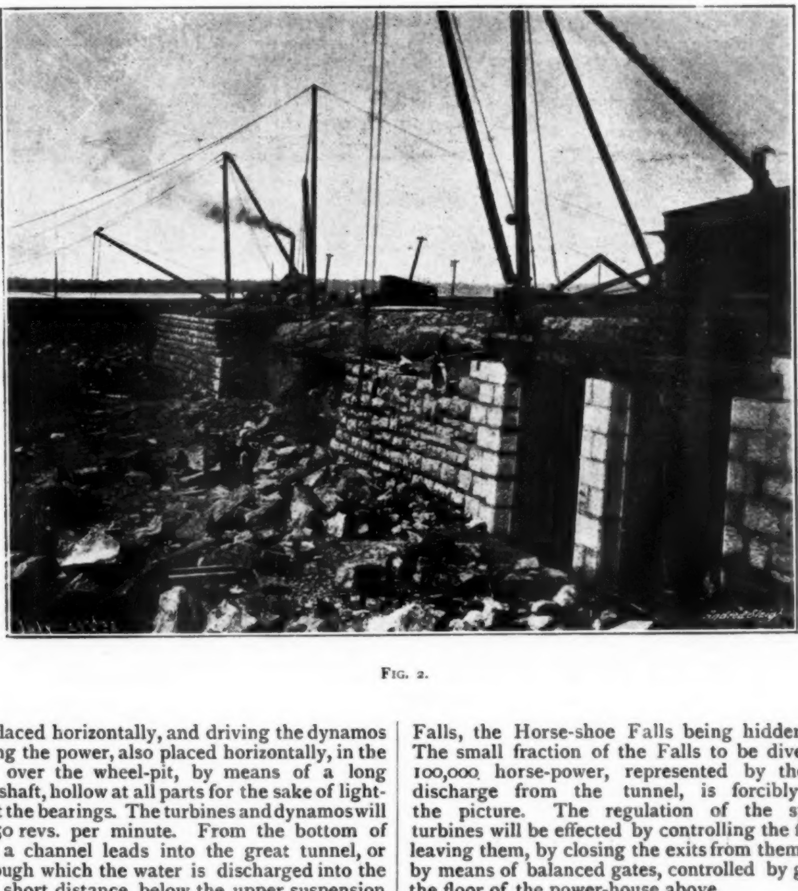

FIG. 2.

type, being placed horizontally, and driving the dynamos for distributing the power, also placed horizontally, in the power-house over the wheel-pit, by means of a long vertical steel shaft, hollow at all parts for the sake of lightness except at the bearings. The turbines and dynamos will revolve at 250 revs. per minute. From the bottom of the wheel-pit a channel leads into the great tunnel, or tail-race, through which the water is discharged into the lower river, a short distance below the upper suspension bridge, after it has passed through the turbines. This tunnel, now completed, is a great work, but only commensurate with the scale on which the whole scheme has been undertaken. It has a capacity sufficient for discharging the water from turbines aggregating about 100,000 h.p., which is the figure towards which the Cataract Construction Company is working at present, and has been constructed with a consideration for durability such as will arrest the confidence of those intending to make use of the power,

Falls, the Horse-shoe Falls being hidden from view The small fraction of the Falls to be diverted for the 100,000 horse-power, represented by the *maximum* discharge from the tunnel, is forcibly shown by the picture. The regulation of the speed of the turbines will be effected by controlling the flow of water leaving them, by closing the exits from them more or less by means of balanced gates, controlled by governors on the floor of the power-house above.

Passing now from the hydraulic part of the works to the electrical or distributing part, we are presented with one of the most interesting and important developments in electrical engineering practice of the present day.

In the year 1890 the Cataract Construction Company invited selected engineers and engineering firms to consider the problem of distributing the power, and appointed a commission, called the International Niagara Commission, to examine and consider all the projects sent in. It

consisted of Lord Kelvin (then Sir William Thomson) as president; Dr. Coleman Sellers, of Philadelphia; Prof. E. Mascart, Paris; Colonel Theodore Turrettini, Geneva; and Prof. W. Cawthorne Unwin, F.R.S., as secretary. Funds were placed in their hands for the purpose of paying a fixed sum to each competitor sending in a scheme of sufficient importance, and awarding prizes. Meetings of the commissioners were held in London, but no decision was come to as to whether compressed air or electricity should be used—the two means of distributing the power for which schemes were submitted,—and they were not convinced of the superiority of an alternating current over a continuous current system of electrical distribution. Since the commission dissolved, however, a decision was come to in favour of the adoption of electrical distribution, and Prof. George Forbes, F.R.S., being appointed electrical consulting engineer, the outcome has been the adoption of the scheme originally submitted to the commission by him in 1890 and rejected at the time by every one of the commissioners. In that scheme it

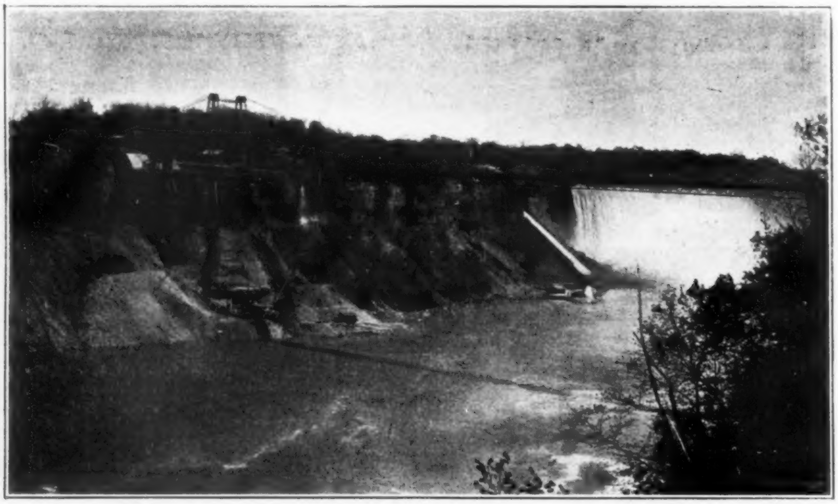

Fig. 3.

was insisted that alternating currents must be used, that the two-phase system should be adopted (that is, one employing two currents which differ from each other with respect to time by 90 degrees or a quarter of a complete period of alternation—when one has a *maximum* value, positive or negative, the other is a zero, and *vice versa*), that, using only machinery on the market, 2000 volts should be the pressure for local work, and step-up transformers be employed for raising the pressure for transmission to Buffalo (eighteen miles distant), and that the motors for converting the electrical power into mechanical power at the far ends of the lines should be synchronising motors, Tesla two-phase motors, and motors with commutators and laminated fields. This briefly describes the system to be now adopted; and it is interesting to note the conversion of the commissioners appointed by the Cataract Construction Company, with one notable exception, to viewing with favour the adoption of the alternating current in preference to the continuous current. But the difficulties connected with the insulation of the dynamos from the earth, which is necessary when using a number in series (an arrangement required in the continuous current system to increase the pressure to the figure necessary for economical transmission), and the admirable facility with which the alternating current can be reduced from high to low pressure, and *vice versa*, for the various requirements—such as electric traction, electro-metallurgy, motive-power and lighting—by that machine which does its work without mechanically moving parts—the alternating current transformer—are strong points in favour of the use of alternating currents. The question of motors is, on the other hand, a strong one, ordinarily, in favour of continuous currents. But when the frequency of the alternating current is low, as is to be the case at Niagara Falls, most of the advantages of continuous current motors over alternating current motors disappear, and the operation of many alternating current motors, already existing, is facilitated.

In regard to the frequency of alternation of the currents to be adopted at Niagara Falls, we find a very marked departure from existing practice. The frequency hitherto used has been from 70 to 100 periods per second in Europe, and 133 in America. There is an exception—that of Messrs. Ganz and Co., of Buda-Pesth—who have adopted 42 periods per second. But the frequency to be used at Niagara Falls will eclipse all, inasmuch as it is to be one of 25 periods per second; and it may be remarked here that one of 16 periods per second would have been adopted, had not the weight of the machine for this periodicity been too heavy for the hydraulic piston (which supports the whole weight of the revolving parts of the turbine and dynamo, and the shaft connecting them, using the head of water driving the turbine, the thrust-bearing shown in Fig. 1 being merely for preventing motion vertically), using the induction in the iron desired by the manufacturers of the machines, which is lower than that which the Cataract Construction Company's electrical consulting engineer would have preferred.

The advantages to be derived from the use of so low a rate of alternation are many. One has already been mentioned here, namely, the increased number of alternating current motors which become available for use, to which may be added the further great advantage of an improved efficiency in the motors. But probably the greatest advantages of a low frequency are to be found

in connection with the conductors for the transmission of the power. There are many difficulties experienced with high frequency currents which are either largely mitigated, or entirely removed, by the adoption of a low rate of alternation. There is, first, the tendency of alternating currents to confine themselves to the outside of the conductors carrying them, thereby increasing the resistance, an effect increased by augmenting the frequency; secondly, there is the impedance of the line, due to the magnetic field formed between the go and return wires of a circuit, which is also increased by raising the frequency; another is the tendency to discharge from a conductor, shown so well by Dr. Lodge's experiments with extremely high rates of alternation, which is less marked the lower the frequency; a fourth is that tendency to break down solid insulators, shown by Mr. Tesla, again using currents of extremely high frequency, which is reduced the lower the rate; and lastly there is the loss due to capacity, both owing to static charge, and, combined with the self-induction of the circuit, resonant effects, which is reduced more and more the lower the frequency is made. There is one important objection, in general, to the use of a slow period of alternation, and this is that, with the frequency to be used at Niagara Falls, flickering of lamps, both arc and incandescent, is perceptible. But this objection is very easily overcome by changing the alternating current into a continuous current, as will have to be done for other purposes at Niagara Falls, which may be accomplished in one or two ways, to be mentioned later. This objection, too, had not the same weight at Niagara Falls as it might have at other places, as most of the power transmitted will be used for motive-power purposes.

The electric pressure selected for use in the neighbourhood of Niagara Falls, and for transmission to Buffalo—one of the first more distant places to be supplied with power—will be 2000 volts at first, for the former, and probably 20,000 volts for the latter. As regards the means of obtaining the 20,000 volts, it is much to be regretted that the inability to obtain from American manufacturers a guarantee for machines constructed for such a pressure, they having never supplied machines at a higher pressure than 2000 volts, has necessitated the adoption of step-up transformers. The consequence is that economy has had to give way to expediency, and this has again made itself felt in the pressure of 2000 volts decided upon, as probable, for the local distribution. The use of the extra high pressure, even here, would have obvious advantages. One would be the resulting uniformity in the whole system, local and distant; and a second, the saving to be effected in the amount of copper in the conductors. It is a significant fact in support of this contention that, to put in the most economical section, using 2000 volts, will require 3 sq. in. of copper for each conductor, or 12 sq. in. for each 5000 horse-power dynamo.

The dynamos for generating the power in two alternating currents differing in phase by 90°, at 2000 volts, will be mounted directly on the top of the turbine shafts. They will be of 5000 horse-power each, and were designed specially for the work by Prof. George Forbes, as the Company's electrical consulting engineer, three being now made by the Westinghouse Electric and Manufacturing Company, of Pittsburgh, Pa. In them the armature is fixed, the field magnet, formed of a nickel-steel ring, 12 ft. 9 in. in diameter, 4 ft. 2 in. high, and 6 in. thick, with the pole-pieces pointing radially inwards, revolving outside. In this way the pole-pieces are well held in against centrifugal force, and, moreover, the magnetic pull between the pole-pieces and armature *opposes* the centrifugal force of the revolving field magnet. The nickel-steel ring with the pole-pieces is suspended from a steel spider with eight arms, which spreads over the top of the armature like an umbrella, being keyed to the solid steel shaft passing through the centre, and attached to the ring by studs and nuts. The attendants will be able to enter the interior of the armature at all times, whether the machine be running or not, for the purpose of attending to the two bearings inside, and the collecting rings on the under side of the spider and the brushes, for passing the current to the exciting coils, &c.

From the dynamos conductors will be led, in conduits in the floor of the power-house, to a large subway running the whole length of the house and opening into a large cellar underneath it, in which will be placed the transformers for raising the pressure for the transmission of the power outside, and other apparatus.

The means adopted for running the conductors between the power-house and the spots where the power is to be utilised is of the most satisfactory description. Bearing in mind the very real troubles likely to arise with a pole line from lightning, wind, and frost, including the formation of sleet upon the wires and insulators, the Cataract Construction Company abandoned this cheapest form of construction, and decided to build a subway large enough to carry the conductors, and allow of a man walking or travelling on a trolley along the whole length. The length built up to the present extends from the power-house to the Pittsburgh Reduction Company's works, to be devoted to the production of aluminium, and one of the first places to be supplied with power, a distance of 2500 feet. This subway, which may eventually be extended to Buffalo, is built after the design of the Cataract Construction Company's electrical consulting engineer, and is of concrete 9 or 10 inches in thickness. The height inside is 5 ft. 6 in. It is of the horse-shoe shape, as shown in Fig. 4, which is from a photograph of the actual work. Iron castings are embedded in the sides every 30 ft., on which are bolted brackets carrying oil insulators to carry the bare copper conductors. In front of the conductors, on each side, will be placed screens formed of wooden frames 10 ft. long, on which will be stretched open metal, covered with plaster to within about a foot of the top, which will there be left open to allow of inspection of the conductors behind. Down the centre space, 22 inches wide, will be a track for an electric trolley, with a conductor between the rails. Drainage, &c., has been well provided for, manholes built to the surface of the ground, and each casting carrying insulators is put to earth. The subway will probably be artificially dried by forcing a current of dry air through it. In this way a very satisfactory piece of work, both from the point of view of efficiency, and that of safety, has been undertaken and practically completed, making this part of the work of the same permanent character given to the rest of the undertaking.

It only remains to say a few words with regard to the motors to be used for converting the electrical power into mechanical power at the far ends of the lines, and the other purposes to which it will be put.

For electric lighting the current, as already stated, will have to be transformed into a continuous current on account of the low frequency of alternation adopted; a continuous current will also be required for other purposes, such as street railways, metallurgical works, and probably the working of the canal boats on the Erie Canal running from the Niagara River above the Falls to the Hudson River at Albany, 350 miles distant. This continuous current can be obtained in several ways, one being the well-known method of driving a continuous current dynamo by an alternating current motor; a second by using a commutator, placed where the continuous current is required, and there rotated. With this latter method, besides all the advantages of the alternating current being retained up to the point where the continuous current is required, the rectification can be effected with very inexpensive machinery and without

serious loss. Although no commutator for this special purpose is at present on the market, the solution of the problem has been practically achieved, and may be expected in the immediate future to result in important developments in the electrical distribution of power.

With both the continuous current and the alternating current of low frequency, then, for use at the far end of the lines of suitable pressure, the pressure having been reduced from that on the line wires by transformers, as at the transmitting end it was increased, continuous current motors can be used for power work where most suitable; the current can be used for electro-metallurgical work and for electric lighting in the ordinary well-known ways, and the alternating current can be used in motors direct, without rectification, everywhere else.

Already a great number of applications for power have been made. As before noted, the Pittsburg Reduction Company has started works for the production of aluminium, and will be supplied with power to the extent of, at present, 7000 h.p., at 150 volts. The Niagara Falls Paper Company have erected a mill on the lands of the Power Company, for the making of their wood-pulp, and have sunk their own pit for turbines to the extent of 6000 h.p. The Company will take water from the main canal, and lease the right to use the great tunnel of the Niagara Falls Power Company as a tail-race. This mill, as a power consumer, is representative of a type which will probably use largely the cheap power at the Falls, needing as they do power continuously day and night. Synchronising alternators, as motors, could with effect be used in such cases, hardly ever requiring stopping and starting as they would; and they are of high efficiency. The high pressure might be used in some of these cases, without transforming down, in addition. Applications for power have also been made from Albany, 350 miles from the Falls.

FIG. 4.

Large as is the extent of the operations described above, it is by no means all that is in contemplation, or even being now prosecuted. On the same side of the Falls, rights of way have been obtained for driving a second tunnel, of the same capacity as the first—namely, 100,000 h.p.—and on the Canadian side powers have also been granted to the Company to use the water-power there, the extent contemplated to which it will be used reaching, it may be, 250,000 h.p. Altogether the total amount for which concessions have been granted amounts to 450,000 h.p., which will involve the abstraction from the Falls of about 12 per cent. of the water. But, large as this may seem at first sight, admirers of the Falls, from the æsthetic point of view, will be glad to hear that it is thought that the diversion of this amount will not be noticeable to visitors to the Falls. And the Niagara Falls Power Company have limited their demands on the side above the American Falls to the 200,000 h.p. It will no doubt be a long time before the full amount for which powers have been obtained will be taken up. What may lie in the future it is impossible to forecast. But, so far, lovers of nature need fear little that they will be deprived of this great work of hers; they will still hear its thunder, be able to watch its ceaseless changing aspects, and revel in the other beauties of this mighty cataract.

NOTES.

THE first (or gentlemen's) soirée of the Royal Society is announced for Wednesday, May 2.

THE Duke of Bedford and Mr. Spencer Pickering, F.R.S., have arranged to start an experimental fruit station, in order to investigate both scientifically and practically the culture of hardy fruits. About twenty acres of land in the neighbourhood of Woburn Abbey have been set apart for the experiments, and the services of an able horticulturist, who will act as local manager, have been secured.

PROF. J. J. SYLVESTER, F.R.S., has been elected one of the twelve foreign members of the Italian Scientific Academy, founded in 1782, called "Dei Quaranta." Among the other foreign members of this Academy are Prof. Helmholtz, Lord Kelvin, Prof. Huxley, and M. Pasteur.

DR. J. R. REYNOLDS, F.R.S., has been re-elected President of the Royal College of Physicians.

THE death is announced of Dr. E. H. Jacob, Professor of Pathology in Yorkshire College, Leeds, at the early age of forty-four.

THE death occurred last week of General Favé, Academicien Libre of the Paris Academy of Sciences, and for a long time head of the Ecole Polytechnique, where he was Professor of Military Art and Fortification.

WE regret to record the death of Mr. W. Pengelly, F.R.S., at Torquay, on Friday last, at the age of eighty-two. He was the author of various papers on geological and other subjects, and his exploration of Kent's Cavern, carried out under the auspices of the British Association, was of extreme importance in establishing the existence of prehistoric man. He also accumulated and arranged a fine collection of Devonian fossils, which, under the name of the Pengelly Collection, are now in the Oxford University Museum. The President and Committee of the Torquay Natural History Society intend to appeal to the scientific world for funds to build a new lecture-room to their museum, to be called the Pengelly Memorial. Mr. Pengelly

was the founder of the Society, and acted as secretary for forty years.

IT is stated that the Municipal Council of Bry-sur-Marne, near Paris, has decided to erect a monument to Daguerre, the inventor of photography.

A CHAIR of Bacteriology is to be established at Erlangen, and Dr. Hauser, now Privat-docent in that University, will, the *British Medical Journal* states, probably be invited to occupy it.

THE legacy of 100,000 francs, placed at the disposal of the French Government by M. Giffard, has been assigned by the Minister of Public Instruction to the laboratory of the International Society of Electricians.

MR. SCOTT ELLIOT, who left England for Uganda last September, reached Usoga, on the northern shore of the Victoria Nyanza, in December. He proposes to explore the botany, geology, and natural history of the great mountain chain of Ruwenzori.

THE *Ceylon Observer* reports that at the annual meeting of the Planters' Association, held at the end of last month, it was resolved "that the Government be asked to arrange for the appointment of an entomologist to be attached to the Colombo Museum."

THE tenth congress organised by the National Horticultural Society of France will be held at Paris during the General Horticultural Exhibition, between May 23 and 28. Among the special questions to be discussed are the following:—Chlorophyll in relation to the vigour of cultivated plants; capillarity in relation to the preparation of the soil; the means of promoting the nitrification of nitrogenous substances, and of rendering the nitrogen more readily assimilable.

A REUTER's telegram states that Mr. Theodore Bent and his party, on their return from their archæological expedition to Hadramaut, had reached the coast at Sheher, east of Makalla, on March 3. All were in good health, but the journey seems to have been accompanied by considerable danger. They were attacked on several occasions by hostile tribes, but appear to have made good use of their time traversing and, doubtless, mapping a large area of the interior.

THE annual dinner of the Institution of Civil Engineers was held on March 17, in Merchant Taylors' Hall. Mr. Alfred Giles occupied the chair, and among those present were Lord Kelvin, Sir F. Abel, Sir George Stokes, Sir F. Bramwell, Sir Douglas Galton, Sir John Fowler, Prof. Kennedy, Mr. J. W. Hulke, Sir R. Rawlinson, Mr. Alex. Siemens, Dr. James Riley, and Dr. Pole. The institution now numbers as many as 6000 members, and has offshoots in various branches of the engineering profession—marine engineers, naval architects, iron and steel founders, telegraph engineers, &c.

THE following are among the lecture arrangements at the Royal Institution after Easter:—Prof. J. A. Fleming, four lectures on "Electric Illumination"; Prof. J. W. Judd, three lectures on "Rubies: their nature, origin, and metamorphoses"; the Rev. W. H. Dallinger, three lectures on "The Modern Microscope"; Prof. Dewar, three lectures on "The Solid and Liquid States of Matter"; Mr. John A. Gray, two lectures on "Life among the Afghans"; Capt. Abney, three lectures on "Colour Vision" (the Tyndall Lectures). The Friday evening meetings will be resumed on April 6, when a discourse will be given by Prof. Victor Horsley on "Destructive Effects of Projectiles"; succeeding discourses will probably be given by Prof. J. J. Thomson, Dr. J. G. Garson, Prof. H. Marshall Ward, Dr. G. Sims Woodhead, Prof. A. M. Worthington, Sir Howard Grubb, Prof. Oliver Lodge, Prof. C. V. Boys, and others.

THE Committee appointed by the Secretary of State to inquire into the best means available for identifying habitual criminals have issued their report. The system of identification recommended for adoption embodies the practical results of Mr. Galton's investigations, and M. Bertillon's system of classification. It is proposed (1) to photograph prisoners as at present, stress being laid on the necessity of obtaining a perfectly clear side photograph showing distinctly the profile and the form of the ear. (2) To take the five measurements required for purposes of classification, namely, the length of the hand, the width of the head, the length of the left middle finger, the length of the left forearm, the length of the left foot. The measurements should be taken with the same instruments as in France, and should be stated in millimetres, so as to facilitate identification in international cases. (3) To take the finger-prints by Mr. Galton's method. (4) A description should also be taken as at present, but somewhat briefer, including the height in feet and inches, colour of hair, eye and complexion, and the distinctive marks. To carry out these suggestions the establishment of an Anthropometrical Registry is proposed. The Committee are strongly of opinion that it is essential to the complete success of the registry to secure the services of an expert practised in the methods of scientific anthropometry. It is certainly desirable that the English Anthropometric Office should from the first have the advantage of scientific guidance not inferior to that enjoyed by the French Service d'Identification.

M. MARCEL DUBOIS, in a series of articles recently concluded in the *Annales de Géographie*, has investigated the classification of rivers according to size. He points out the unscientific nature of a classification by length or volume alone, and proposes, in place of the uncertain methods hitherto employed, to classify river-systems according to the ratio which the whole annual discharge bears to the area of the drainage basins. This permits of a sub-classification according to climatic zones and varieties of vertical relief. Thus tropical islands have the largest rivers of all, on account of the great rainfall and the small area of the land. Peninsulas in tropical regions come next, but when great continents are considered the configuration of the land comes very prominently into play. Thus in Africa the plateau-structure favours a storing-up of rainfall in lakes and in the upper-courses of rivers barred by cataracts, while in South America the vast plain of the Amazon presents on the grandes scale a system of direct drainage, the whole water-supply flowing without interruption to the sea.

THE *Illustrated Archæologist* for March retains the high character of its predecessors as regards the number and quality of the illustrations. Mr. Edward Lovett's article on prehistoric man in Jersey contains figures of flake-knives, scrapers, drills, piercers, spear-heads, and arrow-heads of flint found in a cave in the high and rugged cliffs near Plemont and Greve-de-Lecq. The height of the cave-floor above the present sea-level is sixty feet. Some exceedingly interesting objects were obtained from a layer of very dark-coloured carbonaceous matter found on the floor, and representing the remains of the last fire used in this ancient dwelling-place. They consisted of several calcined shells of the common limpet, some fragmentary remains of bone, and a few molar teeth of a cervine animal. The most interesting find in the ash, however, was a calcined nodule of iron pyrites which had probably been used with a flint flake for making the necessary spark to kindle the fire. This carries the flint-and-steel back to a very remote period, and gives a hoary antiquity to the tinder-box or its contents. In the whitish clay on the floor of the cave more than a thousand flints were found, every one of which bore, more or less, abundant

traces of careful chipping or flaking. The implements described and figured by Mr. Lovett do not belong to a highly-finished type; indeed, from the enormous number of flakes and chippings associated with them, it is highly probable that the cave was a neolithic workshop. The opinion is expressed that, at the time when the cave was inhabited, Jersey was probably joined to France, and perhaps France to England, which may explain the presence of chert from Portland.

THE current number of *L'Astronomie* contains an article by M. J. R. Plumandon on the application of meteorology to the art of war. The author quotes a number of passages from works of military history, showing how a foreknowledge of the weather for a day or so in advance would probably have changed the issue of certain engagements. With the view of facilitating weather predictions, and of utilising them for military purposes, the author has invented a meteoroscope, which is made by M. Richard, of Paris; it is an aneroid having a dial giving 160 simple predictions according to the reading of the barometer, the wind direction (as shown by the clouds), and the season. It is apparently similar in principle to a synoptic table published by the author some years ago, in which an index, when made to point to the wind direction, gave at right angles the direction of the centre of low pressure (Buys Ballot's law), then in concentric circles was given the probable weather for certain barometric conditions and for the particular season, based upon average conditions obtained from a large number of actual cases. The plan is founded upon scientific principles, but the apparatus can only be regarded as a popular indicator of possible changes in accordance with certain general types of weather.

MR. J. J. HICKS has sent us an account and some readings of Bartrum's open-scale barometer. The lower part of the instrument is like an ordinary mercurial barometer, and near the upper surface of the mercury the tube is enlarged, while above the surface it is again reduced and continued upwards for a length of 27 inches or more. The narrow tube above the mercury contains a red fluid, the upper end of which gives the barometer reading; a rise of mercury in the enlarged part of the tube causing a much greater rise of the fluid in the upper tube. The arrangement is very ingenious, and the readings agree well with the mercurial barometer reduced to a temperature of 62°, after the application of certain corrections, but we do not see why the correction should not be altered to agree with the standard temperature of 32° instead of 62°. By the adoption of artificial inches, and adjustment at some neutral point, the error for capacity might possibly be eliminated. An inch of mercury is represented on the scale by about 9 inches, and it is claimed that this long range enables a reading to be taken to one-thousandth of a mercurial inch without a vernier. The instrument appears to be more reasonable and accurate than other large scale barometers hitherto introduced, and is certainly more handy.

THE best method of using oil in calming troubled waters is thoroughly investigated in a pamphlet entitled "Die Lehre von der Wellenberuhigung," written by Dr. M. M. Richter. The author calls attention to a fact of paramount importance, viz. that the quieting effect of all oils or soaps used is in direct proportion to the amount of free oleic acid they contain. The chief desiderata in an efficient material for the purpose are chemical and physical stability, safety, and speed of expansion over the surface of the water. Such a substance would be found in free oleic acid dissolved in methyl or hexyl alcohol. The advantage of the alcohol is twofold. It prevents the solidification of the oleic acid at 4° C., and it greatly increases the rate of expansion. The latter depends, as the author shows, not so much upon a difference of surface tension as upon the solubility of the expanding surface in water. The observed fact that the more viscous oils are more effective than the more mobile ones, is accounted for by the process of manufacture. Olive oil is prepared by pressing out the olives in the cold, while the various fish oils are prepared at high temperatures, and are much more efficient, owing to the decomposition of the oleic glyceride into glycerine and free oleic acid. But to save the prejudices of experienced navigators, who have found the more viscous oils answer their purpose better, Dr. Richter recommends that the oleic acid mixture be kept as viscous as possible. The force with which a drop of oleic acid spreads over the surface of sea water is sufficient to arrest the motion of a log of wood weighing as much as fifteen grams, when blown by a fairly strong wind, and even to start it in the opposite direction.

AT a recent meeting of the Société Française de Physique, M. Pellat read a paper on the point of application of electromagnetic forces. In the classic experiment of Foucault, where a disc of copper turns between the poles of a magnet, the electromagnetic forces acting on the induced currents, which are developed in the moving disc, do not perform any work, as can be seen from the following consideration. If we rotate the disc by expending an amount of work W, say by means of a falling weight, when the driving force ceases to act, the disc will be rapidly brought to rest. If now the disc is brought back to its initial state by the removal of the quantity of heat Q which has been developed, then $T = JQ$ where T is the total work done by external forces on the system (disc). Now T is made up of two parts: (1) the work W supplied by the falling weight, (2) the work (x) performed by the electromagnetic forces (also external forces, since we are not considering the magnet as forming part of the system under consideration). Therefore $W + x = EQ$; but Violle has shown that $W = JQ$, hence $x = 0$, or the work done by the electromagnetic forces is zero. If, as is usually done, we suppose that the electromagnetic forces act on the matter conveying the electric currents (in this case the disc), then the resultant of these forces is so directed that if the point of application were displaced during the rotation they would perform a negative amount of work. Hence since $x = 0$ the point of application of the electromagnetic forces does not move as the disc rotates. If, however, we suppose that the electric current is the point of application of the electromagnetic forces, then, as has been shown by Nobili, Antinori, and Matteucci, the position of the induced currents being fixed with reference to the magnet, there will be no work done by these electromagnetic forces. To explain how the energy of rotation of the disc becomes converted into heat, it is sufficient to admit that the induced currents (whose positions are fixed in space) exert a kind of friction on the moving disc. The following mechanical device is mentioned by the author as giving a representation of what happens in the electrical case: a copper disc D has its opposite faces pressed between the two arms of a clip P in such a manner that if the clip is held the disc turns with some friction. If the disc and clip are set in movement by the expenditure of an amount of external work W, then, if nothing prevents it, the clip will be dragged round by the disc. If, however, a pin B is placed so that the clip cannot rotate, then the disc will lose its energy of rotation, which will be converted into heat by the friction of the clip. The external force which has acted, *i.e.* the pressure exerted by B on the clip, has performed no work since its point of application has not moved. The quantity of heat developed in the disc and clip will be the equivalent of the work W spent in putting the disc in rotation. Thus the clip represents the induced currents in Foucault's experiment, and the pressure exerted by the pin B on the clip represents the electromagnetic force.

A COPY of the "Handbook of Jamaica," published by Mr. Edward Stanford, has been received. The work is now in its fourteenth year of publication, and comprises statistical, his-

torical, and general information concerning the island, compiled from official and other trustworthy records by Mr. S. P. Musson and Mr. T. Lawrence Roxburgh.

WE have received the first number of a new journal published at Oporto, and entitled *Annaes de Sciencias Naturaes.* The articles are mostly written in Portuguese, and among them we notice one on the flora of Oporto, and another on the birds of Portugal, as well as numerous notes on natural science matters.

MESSRS. MACMILLAN AND CO. have issued the thirty-first volume of the "Statesman's Year-Book," edited by Mr. J. Scott Keltie. The statistics have been well revised, and renewed in cases where recent information rendered such a course desirable. These changes, and the many additions that have been made, bring the volume in touch with current topics and maintain its character as an indispensable work of reference on all statistical and historical matters relating to the States of the world.

SEVERAL new crystallised compounds of hydroxylamine with the chlorides and sulphates of cobalt and manganese have been isolated by Dr. Feldt in the laboratory of the University of Berlin. The chlorides are analogous to the salts containing zinc, cadmium, and barium described some few years ago by Crismer, being constituted upon the type $RCl_2.2NH_2OH$. The sulphates, however, only contain one molecular equivalent of hydroxylamine, but contain two molecules of water of crystallisation. The compound $CoCl_2.2NH_2OH$ is obtained by digesting in a flask through which a current of hydrogen is passing, and which is heated by a water bath, an alcoholic solution of cobaltous chloride with four molecular equivalents of hydroxylamine hydrochloride and a few cubic centimetres of an alcoholic solution of free hydroxylamine. Air requires to be excluded, as brown subsidiary products are otherwise produced. The liquid after a short time deposits the new compound in beautiful rose-coloured acicular crystals, which are fairly stable, and may be preserved for months out of contact with the air. They detonate somewhat violently, however, when heated, owing to sudden decomposition. The manganese salt $MnCl_2.2NH_2OH$ may be similarly obtained, and is more stable than the cobaltous compound. It explodes at 160°. The sulphates cannot be prepared in alcoholic solution, owing to the sparing solubility of the constituent sulphates in alcohol. By employing aqueous solutions salts of a similar nature are obtained, but with the difference of composition above mentioned. Both the salts $CoSO_4.NH_2OH.2H_2O$ and $MnSO_4.NH_2OH.2H_2O$ are similar in appearance to the chlorides, and are considerably more stable in their nature. The most interesting of Dr. Feldt's preparations, however, is a salt $CoCl_3.6NH_2OH$, analogous to the well-known luteo-cobalt-ammonium chloride. When aqueous or alcoholic solutions of cobaltous chloride and hydroxylamine are mixed in contact with air, the rose-coloured precipitate rapidly darkens, taking up oxygen in all probability to form the compound $CoOCl.2NH_2OH$. If this substance is suspended in strongly cooled alcohol, and a similarly cooled alcoholic solution of hydrochloric acid is allowed to fall slowly in, a dark green liquid is produced, which eventually deposits a yellow crystalline powder. This precipitate dissolves readily in dilute aqueous hydrochloric acid, and the solution yields on evaporation the luteo-salt in large, well-formed, bronze-coloured crystals belonging to the monoclinic system. This somewhat remarkable compound is a particularly stable substance, which yields a crystalline precipitate of the corresponding oxalate, $Co_2(C_2O_4)_3.12NH_2OH$, upon the addition of ammonium oxalate solution. Full details of the work are contributed to the *Berichte.*

THE publisher of "Der Botanische Garten zu Buitenzorg auf Java," and "Eine Botanische Tropenreise, Indo-malayische Vegetationsbilder und Reiseskizzen," noticed in these columns last week, is W. Engelmann, of Leipzig.

THE additions to the Zoological Society's Gardens during the past week include a Diana Monkey (*Cercopithecus diana* ♀) from West Africa, presented by Miss L. D. Summerbell; a Wild Cat (*Felis catus* ♀) from Inverness-shire, presented by Mrs. Ellice; two Collared Peccaries (*Dicotyles tajaçu* ♀ ♀); a Globose Curassow (*Crax globicera* ♂) from British Honduras, presented by H.C. Sir Alfred Molony, K.C.M.G.; two Cape Bucephalus (*Bucephalus capensis*); a Cape Viper (*Causus rhombeatus*) from South Africa, presented by Mr. J. E. Matcham; two Crossed Snakes (*Psammophis crucifer*); a Smooth-bellied Snake (*Homalosoma lutrix*); a Rhomb-marked Snake (*Psammophylax rhombeatus*) from South Africa, presented by Messrs. H. M. and C. Beddington; a Crossed Snake (*Psammophis crucifer*); a Hoary Snake (*Coronella cana*); a Puff Adder (*Vipera arietans*) from South Africa, deposited.

OUR ASTRONOMICAL COLUMN.

COMET-SPECTRA AS AFFECTED BY WIDTH OF SLIT.—The unaccountable differences between the spectrum of burning or electrically glowing carbon and the carbon bands observed in comets are successfully explained by Prof. H. Kayser in the *Astronomische Nachrichten.* The chief differences observed between the cometary and terrestrial spectra are the following:—The carbon flutings in the laboratory have a bright edge on the red side, which in the comet spectrum is displaced towards the red. But the maximum of luminosity in the latter is more refrangible than the bright edge in the former. Whereas in the true carbon spectrum the first fluting is the brightest, in cometary spectra the second has often appeared brighter than the first. It is suggested that all these anomalies are due to the fact that in astronomical spectroscopy the slit cannot be closed so far as in the laboratory, when the objects observed are as faint as comets usually are. If we suppose the true spectrum to be that produced by a very narrow slit, we may reproduce the impure cometary spectrum by sliding a wide slit along the true spectrum, and adding up for every position the strips of the true spectrum covered by the slit. We shall thus obtain the portion of the impure spectrum corresponding to the centre of the slit. When the wide slit encounters a band with a bright edge towards the red, it will at once begin to indicate a brightness, which will gradually increase until the slit is completely filled with light. The maximum will then have been obtained, and we see that it does not correspond to the bright edge, but to a line within it. Thus the first two anomalies are accounted for. Finally, if the slit is so wide that it comprehends two carbon bands at the same time, the maximum will not be obtained when the first or the second band occupies its centre, but when the first is just leaving and the third just entering. This accounts for the third anomaly. The experiment may be easily performed in the laboratory, by observing the arc spectra of calcium or iron. On widening the slit the line spectra of these elements show the same positions for the widened lines, but the carbon bands are diffused towards the red, and their maxima are displaced towards the violet.

THE ASTIGMATISM OF ROWLAND'S CONCAVE GRATINGS.—The astigmatism of the Rowland concave grating gives to this form of spectroscope the advantage of showing no dust lines along the spectrum, and of broadening out the spectrum of a star or a small electric spark into a band; but the same property makes it unsuitable for the simultaneous observation of two spectra by the usual method of illuminating one part of the slit with one source of light, and the other part with another source. By a special device, Prof. Rowland has no difficulty in obtaining photographic comparison spectra, but his method only holds good for photography. In a recent pamphlet by Dr. J. L. Sirks (Amsterdam: Johannes Müller), however, it is shown that a slight modification of the ordinary method will enable the desired comparison to be made, at least in the first and second order spectra. The comparison prism, or equivalent arrangement for introducing a second source of light, needs only to be placed some distance from the slit, at a point de-

termined by the intersection of the line joining the slit and the grating, with a line drawn through the focus at a tangent to the circle having its centre in the middle of the line joining the grating with the focus. It is further suggested that the special qualities of a Rowland grating which are due to its astigmatism may be imparted to a "dioptric" spectroscope by giving a slight convex spherical curvature to one of the prisms, so that the instrument becomes slightly astigmatic.

THE INSTITUTION OF NAVAL ARCHITECTS.

LAST week the Institution of Naval Architects held their annual spring meeting, under the chairmanship of Admiral Sir John Dalrymple Hay, one of the Vice-Presidents of the institution, the President, Lord Brassey, being absent abroad. There was an unusually strong list of papers; perhaps almost too strong, for it was impossible to do justice to the sixteen contributions, to say nothing of the formal proceedings and the chairman's address, within the limited space of a three days meeting. Some of the papers might have been referred back to the authors with advantage, notably the two long contributions, one on the detachable ram, and the other on the comparative merits of the cylindrical and water-tube boilers.

The following is a list of the papers on the agenda:—(1) "The qualities and performances of recent first-class battle-ships," by W. H. White, C.B., Assistant-Controller of the Navy, and Director of Naval Construction; (2) "The amplitude of rolling on non-synchronous waves," by Emile Bertin, Directeur de l'Ecole d'Application Maritime, Paris; (3) "The stresses on a ship due to rolling," by Prof. A. G. Greenhill, Royal Artillery College, Woolwich; (4) "On Leclert's theorem," by Prof. A. G. Greenhill; (5) "Recent experiments in armour," by Charles E. Ellis, Managing Director of John Brown and Co., Limited, Sheffield; (6) "The detachable ram, or the submarine gun as a substitute for the ram," by Captain W. H. Jaques, late U.S. Navy; (7) "Leaves from a laboratory note-book: (*a*) some points affecting the combustion of fuel in marine boilers: (*b*) the spontaneous heating of coal," by Prof. V. B. Lewes, Royal Naval College, Greenwich; (8) "The circulation of water in Thornycroft water-tube boilers," by J. I. Thornycroft; (9) "On water-tube boilers," by J. T. Milton, Chief Engineer Surveyor Lloyd's Registry of Shipping; (10) "On the comparative merits of the cylindrical and water-tube boilers for ocean steamships," by James Howden; (11) "Further investigations on the vibration of steamers," by Otto Schlick; (12) "On the relation between stress and strain in the structure of vessels," by T. C. Read and G. Stanbury, assistants to the Chief Surveyor Lloyd's Registry of Shipping; (13) "Steam pressure losses in marine engines," by C. E. Stromeyer, Engineer Surveyor Lloyd's Registry of Shipping; (15) "Experience with triple expansion engines at reduced pressures," by D. Croll; (16) "Fluid pressure reversing gear," by David Joy.

M. Bertin's paper and Prof. Greenhill's second paper were taken as read.

Mr. White's contribution had been looked forward to with some interest, as it was anticipated that a somewhat lively discussion would ensue between the constructors of the Admiralty and naval officers on the question of the rolling of the *Resolution*, a subject dealt with by the author. Although the admirals mustered in some force, the discussion was of a very quiet nature, and the general opinion was that the *Resolution* and her sister-ships are perfectly safe vessels, and quite as well designed in regard to rolling capabilities as the tried battle-ships which have preceded them. That this fact could be shown by scientific reasoning was known beforehand to those acquainted with the elements of design of the ships, and having sufficient technical knowledge to draw conclusions from the premises. Nevertheless the doubts raised by the fact that the *Resolution* had put back to port after encountering a heavy storm in the Bay of Biscay, and the certainly extravagant newspaper reports of the occurrence were an unpleasant feature, especially as they appeared to be shared by a certain number of naval officers. It is well, therefore, that the discussion took place, and the matter has been set at rest. Mr. White's was a very long contribution, far too long for us to attempt even to abstract it here; but it was none too long for the patience of the meeting, as it was full of suggestive matter from beginning to end. The author dealt in a masterly way with the questions, in relation to battle-ships, of draught and trim, stability, metacentric height, curves of statical stability, period of oscillation, bilge keels, behaviour at sea, the behaviour of the *Resolution* in December 1893, performances under steam, manœuvring powers, relative size and cost of *Royal Sovereign* class, and the *Centurion* and *Barfleur* class. Unfavourable comments have been made on the *Royal Sovereign* class—the eight battle-ships of the Hamilton programme, of which the *Resolution* is one—because they have rolled heavily when small vessels have been comparatively steady. This, of course, is a circumstance for which the laws of nature are responsible rather than the designers of the ship; for however talented a naval architect may be, he cannot destroy natural laws, but can only seek to work so that they may be on his side, rather than fly in their face. To this end the constructor attempts to dispose dimensions and weights so that the natural period of oscillation of the ship may not synchronise with the period of waves more commonly encountered. A fair metacentric height is, of course, necessary in order that the ship may have stability, but an unduly large metacentric height tends to lessen the period of oscillation, and thus brings the period of the ship more nearly into harmony with that of waves ordinarily occurring. In fact, excessive stiffness produces undue motion amongst waves, whilst a very steady comfortable vessel might be one in danger of turning over under very small impulses. These facts are well known, of course, to those accustomed to the design of vessels, but they apparently are not fully grasped by many of those who go to sea in ships, to judge by the correspondence called forth by the *Resolution* incident. After the discussion that has been called forth by that incident, and the instruction given in connection with it, a hope may be expressed that "stability" and "steadiness" will not always be taken to accompany each other. The metacentric height of the *Royal Sovereign* class of the barbette type is $3\frac{1}{2}$ feet, and past experience has shown that an excellent combination of stiffness and steadiness has been obtained with metacentric heights varying from $2\frac{3}{4}$ to $3\frac{1}{2}$ feet. It may be taken for granted that it is desirable to give vessels a long period in order to gain steadiness, and with these big vessels the metacentre could be higher than in smaller craft, and, under extreme conditions of lading, the *Royal Sovereign* class could have as great a height as 4 feet without unduly impairing their prospect of steadiness, whilst of course the stiffness would be great. It is worthy of note that the inclining experiments made with the *Royal Sovereign* showed the calculated centre of gravity to be but $1\frac{3}{4}$ inches above the actual position; a result which speaks well for the care with which designs are got out at Whitehall. The period of oscillation of the *Royal Sovereign* with normal weights and $3\frac{1}{2}$ feet metacentric height, is about eight seconds. This accords with the period of battleships which have acquired good reputations for steadiness in times past. Most of the latter ships, Mr. White tells us, have smaller metacentric heights, but they are also inferior in weight and moment of inertia; the latter, it must be remembered, having an important influence on the period of oscillation. Mr. White did not think it necessary to explain to a professional audience the manner in which rolling depends on the agreement between the period of the ship and the period of the wave, a fact that must be apparent to anyone who considers how a child's swing may be caused to oscillate through a wide range by small impulses applied at the right moment. Apparently the *Resolution* fell in with a sea, on the memorable occasion in the Bay of Biscay, which tilted her from side to side just as she herself was inclined to roll, whilst the little torpedo gun-boat *Gleaner*, which accompanied her, and made so much better weather of it, was not "fitted" by the big sea. In more moderate and more ordinary weather the relative conditions might have been reversed. In any case, it is as well to repeat, the *Resolution* at her greatest angle of roll had an ample margin of stability, and there was no reason to fear for the ship, although it was doubtless remarkably uncomfortable on board, and the captain exercised a wise discretion in coming back, having, as he did, an entirely untrained crew under him.

The paper by M. Emile Bertin treats with the subject of rolling of ships from a mathematical stand-point, carrying on the investigation of the question from a point where it was left by the late Prof. Jenkins, in a paper wherein he investigated the maximum effect which takes place at the extreme angle of roll. The author extends the theory to the effect at any intermediate part of the oscillation, and to the case in which the angle of maximum-righting moment may be less than a right angle. The difficulty of exact measurement of rolling is shown by the paper; a fact also well illustrated by Mr. White in the previous

contribution. The ordinary pendulum instrument has been known to give indications 50 per cent. from truth, and it is evident that all statements as to the rolling of ships at sea—other than those obtained by a trained staff of observers with approved appliances—must be taken with a very large grain of salt.

On the second day of the meeting, Thursday, March 15, the proceedings opened with Mr. Ellis's very interesting paper on armour. This was another long contribution, with an appendix which gave results of all firing experiments on nickel steel and Harveyised armour that have taken place, excepting two, and one of these is to be included later. The other was made with a Harveyised steel plate so manifestly inferior as not to be considered fairly within the category. There was not much discussion of results or expression of opinion in the paper, and it would be useless to attempt to abstract the details of the trials. The memoir will remain a standard record of what has been done in this field up to the present time, and as such we must be content to leave it. The discussion which followed was much of the same nature as the paper; but the gratifying fact seemed apparent that at present English makers of armour-plates are somewhat ahead of their foreign competitors. How long it will be before the see-saw of inventive progress will again put another country in the front, remains to be seen, and doubtless depends chiefly to what extent monopoly is allowed to rule.

The leaves from Prof. Lewes's laboratory note-book did not form quite so valuable a paper as we are accustomed to get from him. A good deal that was said about combustion was certainly not new, even to the common engineer who has not made a special study of chemistry, and the many practical points missed seriously detracted from the value of the matter set forth. Thursday evening's sitting was the big one of the meeting, indeed we have seldom seen the theatre so overcrowded as it was when Sir Nathaniel Barnaby took the chair at seven o'clock. The water-tube boiler is *the* great marine engineering question of the day, and there was a prospect of it being fully discussed after the reading of the three papers that were on the list. The boiler has never received the attention it deserves at the hands of engineers, the steam-engine apparently affording a much more interesting field of research. The neglect has carried with it its own punishment, for the boiler has always been the most fruitful source of trouble to the marine engineer. To such an extent has this been the case of late that engineers have perforce had to turn their attention to the less interesting branch of machinery design. The advent of the three-stage compound engine, and the consequent demand for higher pressures, has emphasised the need for a new departure, although the introduction of the corrugated flue and the application of steel to boiler construction has delayed the crisis somewhat. These advantages have, however, been fully worked up, yet still there is a demand for further advance, and a large number of prominent marine engineers appear to think that the water-tube boiler, or pipe boiler—in which the water is inside the tubes, and the fire outside—is the proper solution of the problem. Mr. Thornycroft — the well-known torpedo boat builder, who took the leading part in introducing the locomotive type of boiler afloat—was perhaps the earliest of the present-day advocates of the water-tube boiler in this country to experiment and invent. The result of his labours is that he has produced a water-tube boiler at once safe, quick steaming, light, economical, and durable. The chief point which has led to the attainment of these desirable qualities is that he has been able to combine automatic and sufficient water circulation with small water spaces. His boiler consists of three horizontal cylinders which are placed so that in cross section of the boiler they are at the three angles of an imaginary triangle. The top cylinder at the apex is connected to the two cylinders at the base by two series of curved pipes which form the heating surface of the boiler. The grate is under the base of the triangle, and the whole is enclosed in a smoke-jacket or casing, the chimney naturally being at the top. The products of combustion pass among the tubes, and thence up the chimney. Outside the casing the top cylinder is connected to the two bottom cylinders by a couple of large pipes. The top cylinder may be from a foot to three feet in diameter, according to the size of the boiler; the bottom cylinders are considerably smaller, and the pipes forming the heating surface will be about one inch in diameter. The circulation of water, the chief feature which has led to the success of this steam generator, is obtained in this way:—When the one-inch pipes become heated, the water in them is turned partly into steam, and thus the mass becomes of less specific gravity than the column of solid water in the down-comer pipes outside the casing which connect the extreme end of the top cylinder to the extreme ends of the bottom cylinders. An ascending current of steam and water is thus set up in the tubes, whilst there must necessarily be a descending current in the down-comer pipes to compensate. In this way the water is always travelling round in a continuous stream, up the hot steam generating pipes, and down the colder down-comer pipes outside. Mr. Thornycroft has made some very pretty experiments with one of his boilers, which we lately had an opportunity of seeing at his works at Chiswick. He fitted a glass end—made of a number of sheets of plate-glass stuck together by a transparent cement—to the top horizontal cylinder, so that the circulation could be seen and measured. For the latter purpose a notched weir was put in the end of the cylinder, and the flow over it gauged according to the usual formula. The ends of the steam generating tubes could be seen spurting out water intermittently, and the circulation of water is so thorough that it was found by the weir measurements that the circulation of water was 105 times as rapid as the evaporation; that is to say, for each pound of steam generated 105 lbs. of water passed round the system, or, in other words, an equivalent of every pound of water passed 105 times round the cycle before being evaporated. It will be evident that with a volume of water sweeping with a rapidity such as this through the generating tubes, the surface would not be likely to be overheated, whatever the rate of combustion might be, and however fierce the fire. The problem of "drowned tubes" *v.* "above-surface tubes," which appears to be likely to be the burning question of the hour in water-tube boiler circles, is one into which we cannot enter here. Mr. Thornycroft is the leader of the "above-surface" school, whilst his great rival of the lower reaches, Mr. Yarrow, heads the "drowned tube" believers. Undoubtedly the Thornycroftians have more rapid circulation on their side; the question arises whether the Yarrovians have circulation enough.

Mr. Milton's paper consisted of a description of various types of water-tube boiler at present before the engineering world. It contains a large number of illustrations, and forms a valuable addition to his paper on the same subject read at the last summer meeting of the Institution held in Cardiff. Of Mr. Howden's paper it is not necessary to speak.

Friday's proceedings opened with a most interesting paper by Mr. Otto Schlick, whose investigations into the question of vibration of steam vessels will become classic. This further contribution carries the problem a step further, or, perhaps it should be said, enables the engineer to draw his conclusions with greater clearness. By means of a model designed to represent the hull of a steam vessel, the author showed the effect of placing various engines in different parts of the vessel. There were engines of many types—single, double, triple, and quadruple cranks. Pistons were weighted to represent difference in sequence of cylinders, and cranks were arranged at various angles. The model engines were shifted from part to part of the plank which represented the hull of the vessel. This plank, suspended from a frame by helical springs, naturally had a period of vibration of its own, which period was of the first order, *i.e.* with two nodal points; and as the engines were placed upon the nodes or else in other positions, the vibration was intensified or not when the revolutions of the engines reached that critical number, when synchronism was obtained between revolutions and the period of vibration of the plank or hull, according to the now well-known rule. We cannot pretend to give all the varying changes that were rung by Herr Schlick upon his model. Sometimes the changing of the high pressure for the low-pressure piston would start most violent oscillations, or *vice versa*, whilst the shifting of the engines to an equivalent of a few feet in an actual ship would have a really wonderful effect. For the details of these experiments we must refer our readers to the original paper, wherein both naval architects, engineers, physicists, and mathematicians may find matter of much interest.

Messrs. Read and Stanbury's paper is one of that admirable series on the subject of stress and strain in vessels upon which the first-named author especially has devoted so much time and thought. The present is a paper of almost purely professional interest, and is one with which it would be impossible to deal in brief. Mr. Taylor's paper was not read, Mr. Froude, in the absence of the author, giving an abstract. The problem of calculating the pressure and velocity of water at

every point of the immersed surface of a ship, upon the lines and speed being given, is one which will long remain to be solved; but every step towards that end must be of interest, and the best way to proceed is naturally to divest the subject of those elements which tend to obscure its solution, and thus grapple with difficulties in detail. This the author proceeds to do by imagining a set of conditions which by no means exist. Thus, he supposes the surface of the water covered by rigid smooth ice, and the vessel to be flat-bottomed with vertical sides. In this way similar water lines are obtained, and the flow of water will be in plane stream lines only. This simplifies the work, since the methods and formulæ dealing with stream lines in two dimensions are much simpler than those for stream lines in three dimensions. The author proceeds to work out his problem on these lines at some length, and it will be evident from what has been said that it would be impossible to deal adequately with the question in a report such as this; in fact, the paper requires more study than we have been able to give to it up to the present. A short discussion followed the reading.

Mr. Stromeyer's paper discussed steam pressure losses in steam-engines due to various causes, such as friction of steam in pipes and passages; the spring of eccentric straps, rods, and links; inaccuracies in slide valve motion; piston leakage; throttling of steam, &c. Mr. Croll's paper dealt with a subject that has occupied the attention of marine engineers for some time past—the best method of working engines at lower powers; and Mr. Joy described his arrangement for reversing engines by means of an hydraulic cylinder placed inside the eccentric, so that an effect, in some respects, similar to that obtained by means of the loose eccentric is reached without the uncertainty of the latter device, and also with the further benefit of being able to "link up" or to stop the engines by making the eccentric disc coaxial with the shaft. The arrangement is certainly a very taking one, and appears to promise well, though of course such a tried device as link motion will not be ousted until any new arrangement has thoroughly proved its superiority.

The meeting terminated with the usual votes of thanks. The summer meeting will be held at Southampton, in July.

CHOLERA.[1]

IF anyone had undertaken, thirty years ago, to classify the communicable diseases according to whether they are easy or difficult of prevention, he would have doubtless placed cholera, the disease I have chosen for the subject of this lecture, in the front rank amongst the non-preventible, or, at any rate, amongst those diseases that are preventible with very great difficulty; while, if anyone were at the present time to revise this classification, he would find himself in the fortunate position of placing cholera in the front rank amongst those diseases that are easily prevented; in fact, he would be able to tell you that the prevention of the spread of cholera is beset with less difficulty than that of some of the communicable diseases which in towns we have almost constantly among us, as, for instance, pneumonia, diphtheria, measles, and scarlet fever. Nothing could more forcibly illustrate the great advance in practical sanitation than the comparative immunity from cholera in an epidemic form, which this country has enjoyed for the last twenty-five years. By saying "comparative immunity," I am not forgetting that we have had cases of Asiatic cholera in this country during the last autumn, and it is precisely the remarkably limited character of this last outbreak which furnishes the best proof of our advance in sanitation, and gives satisfactory evidence of the correctness of the views on which the measures adopted for the prevention of the spread of cholera are based, and of the justification of placing cholera amongst the easily preventible diseases. To give you an idea of what sanitation has been able to do, and the complete success which attended the practice of good sanitation in preventing the spread of cholera, I will quote in illustration the following remarkable instance:[2]—A well-known fact which has received, unfortunately, a great many illustrations, is this: that pilgrims in India carry the contagium of cholera from the fairs or festivals, to which the disease is brought from the endemic area, to localities which were previously free from cholera. One such fair is particularly notorious, and it has in the past always been a source of the utmost anxiety to the Government of India; this is the great religious festival or Kumbh fair of Hardwâr, a town on the Ganges, but situated outside the endemic area of cholera. This great Kumbh occurs once in twelve years, and it is attended by large numbers of pilgrims, a proportion of these coming from districts in which cholera is always endemic. It has thus frequently happened that this great concourse of pilgrims has been followed by a wide diffusion of the disease. The great Kumbh is principally a religious festival, and is looked upon by Hindus as one of peculiar sanctity, and the very aim and object of their pilgrimage is to bathe in the sacred Ganges, and drink of its holy waters. In 1891, when the last Kumbh fair was held, 800,000 to 1,000,000 pilgrims assembled in Hardwâr; and to get an approximate estimation of the enormous pollution to which the sacred Ganges at Hardwâr is on this occasion subjected, and the great risk from cholera to which those who drink of its waters are exposed, I will mention what Dr. Simpson, the able health officer of Calcutta, states. In describing the scene at the "sacred pool" at Hardwâr—somewhat retired from the rest of the river—to bathe in which and to drink whose waters the pilgrims gather together in such multitudes, Dr. Simpson states that as the bathing of the pilgrims went on the clear stream became a muddy one; that from April 8 to 12 there was always passing through the sacred waters a "seething mass of humanity" in constant motion, passing through the pool at the rate of 400 to 500 per minute. You can easily picture to yourself that a few cases of cholera introduced into such a multitude, living under such conditions, would easily cause not only an outbreak of cholera there and then, but would by the returning pilgrims be carried far and wide. Thus a sanitary commissioner says of the Kumbh, previous to 1867: "Very little remains on record, but that little is a record of disease and death." In 1867, and again in 1879, the festival was followed by an epidemic outbreak of cholera, which on the latter occasion rapidly extended to the western districts. Now, all through the winter of 1890-91 there was much cholera in the north-west provinces and along the pilgrim routes below the hills. So grave was the outlook, that the question of prohibiting the fair to be held in April, 1891, was seriously discussed, and the official opinion of a civil-surgeon, in conformity with that of many other officials of great experience, was to the effect that "the most complete sanitary arrangement will be powerless to prevent the spread of cholera should the contemplated fair at Hardwâr be permitted to take place." Now mark what Mr. Ernest Hart says:

"The fair took place in April, 1891. In December, 1890, proceedings began at and about Hardwâr by the construction of seven bridges, by means of which access to the sacred pool from various parts was much facilitated. The whole of the site was then cleared of undergrowth, all filth was scraped away and removed, and arrangements made for the trenching of night soil. A small army of 1342 sweepers was engaged, and means were taken to prevent their desertion, an event which previous experience had shown to be not unlikely. The whole site was divided into sanitary sections, each with its temporary hospital and its sanitary patrol, every constable of which had his own fixed beat, within which he was instructed to (1) prevent overcrowding, (2) see to surface cleanliness, (3) give notice and remove nuisances, (4) report offenders, (5) remove those sick of infectious diseases, (6) see to the proper location of animals. The sanitary, police, and medical sections were made to correspond, each section being equipped with a special hospital, a number of constables, sanitary inspectors, an ambulance, and a large staff of conservancy men. Each section was thus complete and self-contained, and was directly responsible to the sanitary and deputy sanitary commissioners for the conditions of its own area. The members of the sanitary patrol had each their given beats, over which they exercised a constant supervision, acting also as detectives for sickness.

"The key to the sanitary management of the fair lay in the searching out and rapid removal of all cases of suspicious disease, in the maintenance of perfect cleanliness in the camp, and in the measures taken to prevent all possibility of contamination. Various improvements, however, were made in the conduct of the bathing festival, which were no doubt of great importance.

"The pilgrims coming from cholera-infected districts brought the infection with them, and two people died of undoubted cholera at Hardwâr during the most crowded period, but they were promptly isolated, and the infection did not spread. No

[1] A Lecture delivered at the London Institution on February 15, 1894, by Dr. E. Klein, F.R.S.

[2] This account is taken from Mr. Ernest Hart's description in the *Daily Graphic*, September, 1893.

more cases arose in the town or camp, nor did the disease develop on the track of the dispersing pilgrims. And thus we had the novel experience of a Kumbh fair at Hardwâr without an epidemic of cholera spreading all over the surrounding country concurrently with the dispersion of the gathering."

This is unquestionably one of the most remarkable and brilliant achievements of sanitation in the whole history of cholera. Not only in India, but also in Europe, has it been demonstrated that cholera is a preventible disease. The history and character of the epidemic which prevailed in France, Italy, and Spain between 1884 and 1886, and in Russia in 1892 and 1893, was in no way different from what it used to be thirty years ago in other European countries; it is expressed by stating that the population of villages and towns of whole districts were smitten by disease and decimated by death. But it was different with England and Germany. In 1892 cholera broke out in Hamburg, and asserted itself with great severity; the insanitary conditions of its dock and port population, the neglect in supplying Hamburg with wholesome drinking water – Hamburg being then supplied with unfiltered, polluted Elbe water—brought for Hamburg the long-predicted day of reckoning. In former years the establishment of such a focus of cholera as Hamburg, having such vast communications and intercourse with the whole of Germany, would have been followed by innumerable foci of cholera all over Germany; yet we have the remarkable fact that, with the exception of few cases in a limited number of towns, Germany did not suffer from any further epidemic outbreaks. And in a perhaps more striking manner was the same fact illustrated in 1892, here in England. Grimsby, and Hull also, had cases of cholera in 1893, the former officially at the commencement of September, unofficially some weeks before. The sanitary condition of Grimsby, as revealed at the time by inquiry, and published by the *Times* and the *British Medical Journal*, remind us, in some respects, almost of the times and conditions of a former generation, and the result, as was to be expected, was an unnecessary loss of life through cholera. But although Grimsby carries on a considerable trade by rail and sea with the rest of England, and is in notoriously extensive personal railway communication with the rest of the northern and midland counties (*vide* the enormous fish and oyster trade of Grimsby and Cleethorpes, and the extensive tourist communication with Cleethorpes), with two or three exceptions in which a small local outbreak occurred (Ashbourne, Derbyshire; Rotherham, Yorkshire; North Bierley, Staffordshire), only isolated cases of cholera were noticed in the rest of England. What is this comparative immunity due to, what is the cause of the conspicuous limitation of cholera, that has been experienced lately both in England and Germany? In both countries foci of cholera had been established, sufficient, judging from former experience, for the dissemination and production of cholera in an epidemic form in numbers of localities, and although the transmission and spread of cholera from the first foci, owing to the increased facilities of human intercourse, was possible in a greater degree than in former periods, yet the country remained practically free from cholera epidemics.

Sir John Simon has years back insisted on the importance of considering cholera, as also typhoid fever, as a "filth disease"; that is to say, both in cholera and in typhoid fever the contagium voided with the dejecta of a patient, affected with the one or the other disease, is capable of setting up the disease, if it finds access to the alimentary canal of a susceptible person, either by specifically polluted drinking water or articles of food, or by the instrumentality of the hands that had been in contact with specifically soiled linen or other textile articles.

Since the recognition of these facts it has become an axiom in sanitary science to isolate the patient, to disinfect or destroy not only the dejecta, but all articles that may have become soiled by the dejecta of a patient affected with cholera, to prevent such filth from gaining access to drinking water and to articles of food, and to insist that the hands that have been in contact with such soiled articles ought to be scrupulously cleansed in order to avoid self-infection; in short, to prevent and to avoid the contagium being "swallowed." By carrying out these precepts it has become possible, and, as events proved, it has been successfully accomplished that cholera did not spread epidemically either at the last Kumbh fair at Hardwâr, or in England or in Germany. This success implies two things: (1) the locality, prior to the introduction of a case of cholera, should be in a proper sanitary condition, and (2) on the appearance of a case of cholera the measures for isolation and disinfection should at once be put in practice; there should be no attempt at hiding or ignoring, but boldly and openly the fact should be recognised, and action taken accordingly; for if in any locality even a few cases are allowed to pass undealt with, and supposing the sanitary conditions of that locality be of an inferior character, the dissemination of the contagium and the creation of a number of further and independent foci may in a short time bring about a state of things in which the check of the epidemic spread of the disease becomes a matter of the greatest difficulty —an occurrence which had its illustration both in Hamburg and in Grimsby. Though a great portion of England may claim to be fairly well prepared, as far as general sanitation, drinking-water, drainage, and general cleanliness are concerned, it is notorious that there remain localities which escaped a visitation by cholera during last year; but their luck may not hold out on a second occasion, and a day of reckoning may arrive on which they will be rudely awakened, like Hamburg, to the fact that by their negligence in the past they have to pay a heavy penalty in human life.

Now, it will be asked, is it a fact that those isolated cases which occurred in different localities in England during the last autumn were really cases of true or Asiatic cholera, and that owing to the better preparation and stricter execution in regard to sanitary measures, insisted on by our Public Health authorities, those isolated cases did not spread, and were not followed by further outbreaks of the disease? It must be evident that if those cases were not cases of true cholera—that is to say, if they were of the character of that disease which occurs in each year during the summer and autumn in a sporadic form, known as English cholera or cholera nostras, then the above proposition as to the supposed superiority of our sanitation for the prevention of the spread of epidemic or Asiatic cholera remains as yet untried and has still to be proved. No one, I presume, will deny that we had in September, 1893, true or Asiatic cholera in Hull, Grimsby, and certain other places; the character of the disease, the grouping of the cases, and the high percentage of mortality prove this; besides, it is known that cases of cholera have reached our shores both in 1892 and 1893. Similarly, it will not be denied that the cases that occurred in Rotherham, Ashbourne, and North Bierley were of the same nature; the symptoms, the epidemic character, and the high fatality alone prove this. But what has been questioned is whether the isolated cases which occurred in Retford, Leicester, Derby, Doncaster, Yarmouth, London, and other places, were true cholera. Now, it is agreed that as regards their clinical history and mortality (these were all fatal cases) a distinction between them and typical true cholera could not be drawn. But it is said that (*a*) on account of their occurring as isolated cases, and (*b*) on account of the impossibility of tracing the way in which the infection had been imported, the proof that they were cases of true cholera has not been satisfactorily established.

As to (*a*). If in any locality after the appearance of one or more suspicious choleraic cases there should follow, sooner or later, a gradually increasing number of similar cases with high fatality, the preliminary conclusion that these are cases of true cholera is justified. But whether in any locality one case is followed by others, or remains an isolated one, obviously depends on the condition whether the contagium, either by the prevailing insanitary conditions, or by the laxity of the application of sanitary measures, has or has not been allowed to take a footing and to spread; for if, as stated above, the conditions as to drinking water, drainage, &c. are satisfactory, and if on the introduction of the first case this is at once isolated, its dejecta disinfected and destroyed, and infection from it therefore prevented from being disseminated, it is clear that no further cases would be forthcoming. The epidemic diffusion of the disease depends then on deficient sanitation, and cannot therefore be a distinguishing character between what is true and what is not true cholera. No one doubts that the few cases that were imported from cholera-infected districts in 1891 into Hardwâr were cases of true cholera, yet we saw that owing to the excellent and thorough sanitary measures taken before and during the fair no epidemic occurred; those few cases therefore remain cases of true cholera, notwithstanding the unwonted absence of an epidemic outbreak.

In a like manner it must be evident that numbers of persons that contracted the infection in Hamburg in 1892 travelled to many places in Germany where they sickened of, and some of

them succumbed to, the disease; others came over to England and to London, yet they did not produce an epidemic in the localities in which they arrived or died, for the simple reason that they were looked after, isolated, and their dejecta and belongings disinfected or destroyed. But they do not cease to be cases of true cholera, though they were not followed by others.

The following case, that occurred in England last September, may serve as an illustration. A man, landlord of an hotel in Retford, who for some days was suffering from diarrhœa, had been to Doncaster, where he partook of oysters brought from a cholera-infected locality. Soon after arriving home he was seized with violent cramping pains of the arms and legs, sickness, vomiting, and diarrhœa; the doctor who was called in noticed the altered voice, which was like a whisper; the patient was very restless, and complained of great depression; the evacuations were like rice-water, there was suppression of urine; he rapidly became collapsed, the extremities became cold, and the surface of the body livid and shrunken. He died after an acute illness of fifteen hours and a half. I have read to you the clinical history of this case because it presents the picture of true virulent cholera, such as is described in text-books as a most typical case of Asiatic cholera. It is presumable that the above person became infected by eating oysters, because these were derived from a place where cholera was rife, but it is only presumably so; the man had not been either at Grimsby, Hull, or Cleethorpes, or any cholera locality; but that he suffered from, and succumbed to true cholera, can hardly be doubted, and I shall give you presently further evidence to that effect; and yet this remained, thanks to the prompt sanitary measures taken, the only case of cholera that occurred at Retford. You see, then, that a case remaining an isolated one does not necessarily cease to be a case of true cholera.

As to (*b*). As regards the inability to trace every one of the isolated cases that occurred in the different localities to a previous focus of cholera, and the allegation on this ground that it remains doubtful whether these cases were or were not true cholera. It is unquestionably a great help, in order to make a correct diagnosis and to take the necessary precautions, to trace the manner in which the infection found entrance into a given locality. But, unfortunately, the way in which the contagium of cholera, as well as that of typhoid fever, travels, is not always a straight one or easily followed; in many cases the way can be followed with approximate accuracy, but in others—amongst them some epidemics of undoubted true cholera—the manner in which the contagium was introduced has baffled even experienced sanitarians, and it is owing precisely to such instances (they have occurred both in India and in Europe), that the solution of the problem as to the origin of some of those cholera epidemics is beset with great difficulties, and has called forth a division of opinion amongst epidemiologists. If the problem were of such simplicity as is implied by the assertion, that in every case of cholera we must be able to trace the infection to a known focus, the division of opinion as to the origin of some of the epidemics of true cholera would long ago have disappeared.

Koch first showed that in the rice-water-like dejecta and in the rice-water-like contents of the intestine of a typical case of Asiatic cholera, there occur certain bacteria, which, on account of their shape, were called by him comma-bacilli; he showed that in some of the typical cholera cases, in which the dejecta or the intestinal contents are of what is called rice-water-like character (that is to say, in a more or less translucent fluid are suspended large and small flakes, composed of the detached epithelium lining of the intestinal mucous membrane), the flakes, as also the fluid, contain these comma bacilli in enormous numbers; and that the flakes contain them in a characteristic linear arrangement, occasionally to the total exclusion of other kinds of bacteria, such as may be found inhabiting the normal alimentary canal.

I exhibit here on the screen photographs of the microscopic character of the rice-water-like dejecta of typical cases of Asiatic cholera; one from a case in India, several from typical cases that occurred last year in England. The illustrations show not only a great number of the comma bacilli and a total exclusion of other bacteria, but also the characteristic linear arrangement of the vibrios in the flakes.

It is now agreed by all who have devoted attention to this subject, that such a condition as I have shown you here does not occur in any other acute disease of the alimentary canal in man except in Asiatic or true cholera. A large number of cases of cholera nostras, or English cholera, have been subjected to examination abroad and in England in non-cholera years, and the result was always the same—viz. a condition such as I described and showed to you does not occur in them. So much so, that all pathologists agree that, supposing a case presents the principal symptoms of cholera, inclusive of the rice-water-like dejecta, if the flakes suspended in the fluid portions of the dejecta show under the microscope crowds of the comma bacilli, particularly in the above linear arrangement, the diagnosis "true cholera" is fully justified. Whether a case of this kind is an isolated one, and whether we are able or unable to trace the way in which the infection has come about, does not, to my mind, alter the diagnosis in the slightest degree. We may be successful in putting our finger on the probable or demonstrable path on which the cholera infection travelled, or we may be baffled in this attempt; we may say—as in the cases that occurred in Hull and Grimsby, in Rotherham, Ashbourne, North Bierley, and elsewhere—here we have a succession of cases presenting all the clinical and pathological characters of true cholera, showing the high fatality found only in true cholera; the flakes of the rice water-like evacuations show the microscopic characters observed only in Asiatic cholera; therefore we are dealing with true cholera, and we do not further trouble ourselves (for the object of making correct diagnosis) with finding out how the first case was introduced, particularly if we remember that most of these places, owing to their situation, may have been exposed to importation of the contagium from cholera-infected localities. Or we may say, as in the Retford case, we presume that the patient, having partaken of oysters which came from an infected locality, caught the infection through these oysters, and the case, presenting all the clinical and pathological characters of virulent true cholera, and the flakes of the intestinal contents showing the microscopic characters found only in Asiatic cholera, must be one of true cholera, notwithstanding that the case is for Retford an isolated one. But I fail to see how the assertion can be justified, that has been repeatedly made during the last autumn, of various isolated cases occurring in different localities—Leicester, Derby, Westminster, and others—viz. the assertion that these cases, which were all fatal, which presented the symptoms and pathology characteristic of virulent true cholera, and which showed in the flakes of the rice-water-like dejecta the microscopic appearances characteristic of, and found only in, true cholera. The assertion, I say, that these cases cannot be true cholera, because we were not able to trace the manner in which infection was introduced, and because they have not been followed by other similar cases, cannot be accepted.

I take for illustration the noted case of the woman, the cleaner in the House of Commons; she died in Westminster last September, after a very short illness; the symptoms were those of true cholera; the pathological condition of the intestine, the microscopic character of the flakes of the rice-water-like dejecta were such as are found only in typical cases of true cholera, and in no other known acute disease of the intestine; but the manner in which she contracted infection could not be discovered, nor was this case followed by others; rigorous sanitary precautions were at once applied to the house in which she lived and all that appertained to it.

I show you here the microscopic character of the flakes of the rice-water-like dejecta of this case, and you can see that it presents in a conspicuous degree the characteristic appearances, both as to the number and arrangement of the comma bacilli.

The comma bacilli, derived from cases of Asiatic cholera, when tested by cultivation under the different conditions, such as are used in the laboratory for distinguishing one species of bacteria from another, are admitted on all sides to represent a definite group of organisms, of which the principal distinguishing characters in cultivation and in microscopic specimens are shown in these photographs.

One character of particular interest which these cholera vibrios, or cholera spirilla, or Koch's comma bacilli show, is their behaviour when grown at the body temperature (37° C.) in a solution containing peptone and salt; in this solution they grow well and multiply very rapidly, and produce in it nitrites and indol; the presence of these products can be demonstrated already after a few hours (6–8) by adding to the culture a few drops of pure sulphuric acid; the culture at once assumes a distinct rose-coloured tint; this reaction is called the cholera-red reaction. Now, there are known other species of comma

bacilli or vibrios, which in shape, size, motility, manner of growth in the different media, more or less resemble the cholera vibrios of Koch. Some of them also give the cholera-red reaction, sooner or later, when grown in peptone salt culture.

But there is at present known only one comma bacillus from the diseased human intestine that shows certain cultural characters, that grows at 37° C. in peptone salt cultivation with great rapidity, and gives in very short time the distinct cholera-red reaction; and this is the comma bacillus of Koch, found by him in the human intestine in Asiatic cholera. From this it follows that if in any case of choleraic disease this particular species should by microscopic examination, and by the culture test, be demonstrated as present in the bowel, the conclusion is justified that we are dealing with true cholera.

In those isolated fatal cases of choleraic disease which occurred in different localities in England during last autumn (Leicester, Derby, Westminster, Doncaster, Yarmouth, and others), apart from the symptoms and the pathological conditions of the intestine and the characteristic microscopic appearances as to the distribution of the comma bacilli, this species of vibrio was demonstrated by cultivation, and therefore we are justified in saying that these cases were of the true or Asiatic type, and we are further justified in saying that it was owing to the prompt action of the sanitary authorities that these cases were not followed by epidemic outbreaks.

But while we can state from the bacteriological examination that a particular case *is* true cholera, we cannot affirm with equal reliability whether this comma bacillus plays any and which *rôle* in the causation of the disease; nor that a case in which the bacterioscopic examination does not demonstrate the presence of Koch's vibrios in the intestinal discharges is not true cholera; and this for the important reason that in various epidemic outbreaks of true cholera there occurred in the same locality and at the same time, side by side, with undoubted cases of Asiatic cholera, and presenting the same clinical symptoms, the same pathology, and the same high death-rate, a certain proportion of cases in which Koch's comma bacilli could not be demonstrated. In what respects the bacteriology of such cases differs from cases of sporadic or English cholera, is a subject for future inquiry; at present no sufficient data are at hand.

GEOLOGICAL SURVEY OF THE UNITED KINGDOM.[1]

I.

ENGLAND AND WALES.

Drift Survey.—In the early maps published by the Survey, superficial deposits were generally left unrepresented. The importance of these deposits in questions of agriculture, drainage, water-supply, and public health having at length been recognised, it was determined that in future they should be traced and shown upon the maps. As at first they were inadequately understood by geologists, the mapping of them could not be made wholly satisfactory and complete. But as they came to be more thoroughly studied and more carefully traced, they have been represented with increasing fulness and accuracy upon the maps. It has been thought desirable to revise and complete the earlier drift surveys in the north of England, and to extend these surveys over the other parts of the country where they have not previously been made. This renewed examination of the ground is carried on upon maps of the scale of six inches to the mile, and advantage is taken of it to check, and where needful to correct, the already published mapping of the older geological formations underneath.

As the Geological Survey advanced into the eastern counties of England, the importance of the drift deposits became increasingly manifest. Over large districts indeed it was impossible satisfactorily to delineate on maps the structure and boundaries of the formations underlying the drifts which spread as a deep cover above them. For such areas drift maps only could be issued.

[1] Annual Report of the Geological Survey for the year ending December, 31, 1892. By Sir Archibald Geikie, F.R.S., Director General. From the Report of the Science and Art Department for 1892. (Some of those portions of the Report which describe the scientific results of the Survey operations during the last few years are reprinted here).

It was not until the original survey of the whole of England and Wales had been completed that the systematic re-survey of the drifts was begun on the six-inch scale, over those areas not previously surveyed for this purpose. In the south-east of England, where the work is under the charge of Mr. Whitaker, it has extended from Huntingdonshire across the counties of Bedford, Hertford, Buckingham, Oxford, Berks, Wilts, Hants, and the south of Sussex.

Tertiary.—The re-examination of the Tertiary areas to the west of London for the Drift Survey has shown the general accuracy of the old mapping, though the boundary-lines have been occasionally improved. In Hampshire and the Isle of Wight more extensive alterations have been necessary. Thus, the Hamstead Beds, in place of occupying mere isolated patches on the high ground, as was believed when the original map was prepared, are now known to cover a large area. This was proved by Mr. Reid, chiefly by the use of portable boring-rods, such as had for some time previously been employed by the Belgian Geological Survey. These tools have also proved of great service in some recent work in the eastern counties, Certain small outliers on the Chalk of Hampshire, shown as Eocene on the old map, have now been placed among the drifts, and have been mapped as "Clay-with flints." Probably here, as is often the case in parts of the London Basin, the so-called "Clay-with-flints" is in great part re-arranged Eocene material.

Cretaceous.—On the older one-inch maps the Chalk was shown as one mass, no attempt being made to indicate its subdivisions. Indeed no such subdivisions were formerly recognised, save a general grouping into Chalk-with-flints and Chalk-without-flints. Sometimes the lowest portion was separately referred to as Chalk Marl. In later surveys, however, advantage has been taken of the opportunity of tracing on the ground the subdivisions that can now be mapped. These are as follows:—

Upper Chalk.
Chalk Rock.
Middle Chalk, with Melbourn Rock (at the base).
Lower Chalk, with Totternhoe Stone.
Chalk Marl.

The separation of the thick mass of Chalk into so many distinct subdivisions has both an economic and a scientific interest. By revealing the actual structure of the Chalk and the outcrops of its several members the new mapping renders essential service in questions of water supply. It likewise indicates the undulations into which, in consequence of subterranean disturbances, the Chalk has been thrown. These undulations, though often too gentle to be safely inferred from surface exposures, are apparent when the outcrops of the several subdivisions of the Chalk are continuously traced.

In the Chalk-area of Hampshire, Mr. Hawkins, by mapping out these horizons, has proved the general accuracy of the interpretation of the structure of that region given by Dr. Barrois. The uprise at Winchester is well marked, Lower Chalk being there brought to the surface. The folds traversing the Chalk in the western part of the Hampshire Basin, though more strongly marked than those of the London Basin, can only be satisfactorily made out by mapping the subdivisions of the Chalk. Some of the ruptures attendant on the plication of the rocks, so marked in Dorsetshire, are prolonged even into Sussex, and have been detected by Mr. Reid as far east as Eastbourne, where on the foreshore the Cretaceous strata are repeated by faults and overthrusts.

It seems not impossible that the detailed and accurate mapping of the disturbances in the Chalk may ultimately give a clue to the depths of the underlying Palæozoic rocks, a question of the utmost practical importance in regard to the tracing of coal-bearing deposits beneath the south of England.

In 1891 phosphatic Chalk, closely resembling that which is commercially worked in the North of France and in Belgium, was noticed for the first time in this country by Mr. Strahan. The bed is exposed in a Chalk-pit at Taplow, but at present has not been detected elsewhere.

The relations of the Gault and Upper Greensand have long been a matter of uncertainty. Mr. Bristow, the late Senior Director, believed that the two were really one formation, one being locally developed at the expense of the other. Mr. Godwin-Austen regarded the Upper Greensand as a shore-deposit, in part contemporaneous with the Gault of deeper waters. Other geologists have expressed similar views. These

opinions have received support from our recent surveys. The upper part of the Gault becomes more sandy to the west, and was there mapped as Upper Greensand; the clay coloured as Gault in Wiltshire representing only about the lower third part of the Gault of Folkestone. This clay becomes so thin to the west that it cannot be separately mapped.

Mr. Jukes-Browne makes three divisions of the Gault and Upper Greensand series, which are now found to constitute really one formation:—

3. Greensands and Sandstone, and chert beds (Zone of *Pecten asper*).
2. Buff Sands, Malmstones, and silty Marls; the last representing the Upper Gault (Zone of *Ammonites rostratus*).
1. Lower Gault Clays (Zone of *Ammonites lautus and Amm. interruptus*).

The Chert-beds of Wiltshire and Devonshire are local developments in the Zone of *Pecten asper*. They are not found in Dorset, but they attain importance in the Isle of Wight, and were there separately mapped by Mr. Strahan.

In the neighbourhood of Devizes the subdivisions of the Upper Greensand are well marked. The lower one, or "Malmstone," contains, especially in the lower part, colloid silica in the form of small round globules and sponge spicules, sometimes to the extent of from 40 to 50 per cent. of the stone. The upper division, about 70 feet thick, near Devizes, consists of green and grey sands. As these are irregular in thickness, thin out rapidly to the north, and extend as a band in a nearly east and west direction, they may represent an ancient sand-bank. The persistence of the Malmstone over a very wide extent of the "Upper Greensand" of England is a noteworthy fact.

A revived industry of some interest on the borders of Bedfordshire and Buckinghamshire is the extraction of fuller's earth from the Lower Greensand. This deposit is now worked by mines on the flanks of the escarpment. Mr. Cameron has frequently visited these mines, and has described them in papers read before the British Association and elsewhere.

Jurassic.—Some of the most important recent additions to our knowledge of the structure of the Jurassic and Cretaceous rocks of the South of England have been made by Mr. Strahan in his re-examination of Dorsetshire for the Drift Survey. The area known as the Isle of Purbeck has long had a peculiar geological interest, not only from the fact that the Portland and Purbeck rocks there reach their maximum development, but also from its structure. It is traversed by an extremely sharp and faulted monoclinal fold, a continuation of the Isle of Wight monocline, from which, however, it differs in being accompanied by inversion of the strata and much overthrust faulting. This structure may in fact be regarded as an intermediate stage between a simple monocline and a complete overthrust. The deeply indented coast affords unusual facilities for examining the effect of the movement. The old one-inch map, on account of the smallness of the scale, gave merely a diagrammatic view of the structure of the "island" In the re-survey on the six-inch scale both the faults and the subdivisions of the strata have been traced with a detail that was before impossible. In the Isle of Purbeck the principal additions to the map consist in the tracing of the subdivisions of the Cretaceous system. The Lower Greensand, which is so well developed in the Isle of Wight, was known to exist in the Isle of Purbeck also, but its limits had never been determined. It has now been separated from the Wealden group, with which it was formerly confused, and it has been traced westward until it finally thins away, while at the same time the Wealden Shales, which form the uppermost subdivision of the Wealden group in the Isle of Wight, have been traced through the Isle of Purbeck as far westward as they extend.

During the mapping of the Lower Greensand some interesting evidence as to its relation with the overlying Gault came to light. This evidence tends to confirm the conclusions formed during the re-mapping of the Isle of Wight, for the break at the base of the Gault, which was there only suspected, becomes so much more pronounced westwards as to suggest that the base of the Cretaceous system might have been more suitably drawn at the bottom of the Gault than at the bottom of the Wealden group, which is inseparably connected with the Purbeck beds. Moreover, a conglomerate which forms the base of the Gault seems to correspond to the Carstone of the Isle of Wight, which has again been correlated with the Folkestone beds. The suggestion, therefore, made long ago, that a portion of the Folkestone beds should be included in the Upper Cretaceous group receives support. In the Weymouth Peninsula the principal alterations relate to the mapping of the subdivisions of the Chalk as far westward as they are recognisable, and in the tracing of certain subdivisions of the Corallian rocks which are locally developed near Weymouth. The numerous faults of the area have also been followed, with a minuteness of detail which was impossible on the old one-inch map. An interesting result has been obtained from this work. The faults and foldings of the strata, though nearly all agreeing in direction, were found to have been formed at two different periods, the one set affecting the Oolitic rocks but passing under the Upper Cretaceous strata without disturbing them, the other breaking through both Oolitic and Cretaceous rocks alike. The older movements took place between the deposition of the Upper and Lower Cretaceous strata, while the later set were obviously contemporaneous with the Isle of Wight and Isle of Purbeck monoclines, which are believed to be of Miocene age. In more than one case, faults of the later age cross obliquely the older lines of fracture, producing a complication which could only be worked out on the large scale map. The break at the base of the Gault mentioned above seems to have been due to the faulting and upheaving of the rocks during the first of these periods of disturbance. It becomes here a most pronounced unconformability, and the Gault with a thin conglomerate at its base passes over the edges of the Wealden, Purbeck and Kimeridgian rocks in rapid succession.

Triassic.—Advantage has been taken of the prosecution of the Drift Survey across the salt districts of Cheshire and Staffordshire to obtain much additional information regarding the Triassic rocks, especially with reference to their industrial aspects. Mr. C. E. de Rance has collected 208 sections of the salt deposits at Northwich, Middlewich, Winsford and Lawton. He has likewise reduced some mining plans of salt-workings and placed their details on the six-inch maps, and has further collected tables of the levels of the brines at various periods, reducing these levels to Ordnance datum, and thus showing the height of the Upper and Lower rock-salt surfaces.

Carboniferous.—It is in the re-examination of the great coal-field of South Wales that the chief recent operations of the Survey in the Carboniferous system have lain. Sufficient progress has now been made to show of how much practical value a detailed survey of this coal-field will prove to be. Mr. Strahan, who has had charge of this work, soon ascertained that while the great thickness and uniformity of character of the widespread "Pennant Grit" makes it difficult to obtain indications of the geological structure over large tracts of ground, the position of a certain coal-seam known as the "Mynyddislwyn Vein" affords an excellent horizon from which the lie of the other strata can be followed in great detail. He has accordingly devoted special attention to tracing the outcrop of this seam, and the trend of the numerous faults which have been met with in working it. He has had occasion to examine a large series of plans of old workings, and to reduce from these the necessary data upon the six-inch Ordnance maps. When these maps are completed, with all the available detailed information, they will probably afford a sufficient and accurate guide to the depth and dip of the various coal-seams over a large part of the area. The information thus worked out, combined with a precise geological mapping of the ground, will prevent the waste of large sums of money in seeking for coal, by showing exactly the limits within which the seams may be looked for, and the depths at which they may be expected.

Devonian.—Mr. Ussher, in the South of Devonshire, by a sedulous scrutiny of the ground, has been enabled to detect the presence of organic remains previously unnoticed, and by their aid to distinguish and trace the three great divisions of the Devonian system over the district between Newton Abbot and Plymouth. According to his observations, the following grouping may now be considered as established both by palæontological and stratigraphical evidence:—

1. *Upper Devonian.*—Slates, lying on Goniatite Limestone in the Limestone areas, and with local volcanic rocks.

2. *Middle Devonian.*—Slates, Limestones, and Volcanic rocks. The Limestones are developed in a local or sporadic manner, and in the intermediate districts they are replaced by volcanic rocks (the Ashprington Series), while their basement beds are represented by occasional calcareous bands and lenticles in the slate bounding the volcanic series.

3. *Lower Devonian.*—Red and Grey Grits, Sandstones, and

Shales, apparently passing upward into the Middle Devonian Slates by the irregular intercalation of grits with slates.

During the progress of the field-work in South Devonshire a large series of specimens, sent up by Mr. Ussher, has been sliced and subjected to microscopic investigation by the petrographer to the Survey, Mr. J. J. H. Teall, F.R.S., who reports that the detailed examination of the rocks from the metamorphic area of South Devon has brought to light the fact that the previously published descriptions of the green varieties of rock were very imperfect. The specimens which have been least altered by surface-agencies consist essentially of hornblende, albite and epidote. In altered specimens hornblende is more or less replaced by chlorite; and when this is the case calcite is usually present. The hornblende is either uralitic or actinolitic in character, never compact. The felspar is water-clear, and usually without any trace of cleavage or twinning. It has been definitely determined to be albite in one case, and from its uniform character in all the slides examined there can be no doubt that this is the dominant if not the only species present. The association of albite with hornblende, epidote, chlorite and calcite has been described by Lossen in his various papers relating to the modification of the diabases associated with Devonian rocks in the Hartz. Quartz, which had previously been supposed to form an important constituent of these rocks, appears to be comparatively scarce.

Petrographical Department.—The important assistance of the petrographical department has again during the past year been largely extended to the field officers, and has greatly aided their work. Mr. Teall, besides the microscopic and chemical work carried on by him in this office, and the determinations and reports made by him for the guidance of the officers in the field, has during the past year undertaken some field-work himself. As he is specially charged with the investigation of the petrography of the Lewisian gneiss—the most ancient rock in the British Isles—it was considered desirable that he should make himself practically familiar with the minutest details of the complex structure of this venerable formation, and for that end should himself map a portion of its area on the six-inch scale. The Island of Rona, lying between Skye and Ross-shire, was selected for him, and he spent nearly two months in mapping it.

With regard to the ordinary work of the department in the office and to the more important scientific results obtained by Mr. Teall during the last few years, he has at my request drawn up a memorandum, from which the following passages are taken:—The principal work of the petrographical department during the year has been the examination and description of specimens sent up by the officers in the field. Of these 492 have been prepared for microscopic examination and have been described in detail. The total number of Scottish rocks from which sections have been cut is now more than 5000. The system of cataloguing has been improved during the year. Each field officer now numbers his specimens consecutively. These specimens are entered in a book under the name of the officer who sends them up, and a record is kept of the destination of each. Those specimens of which sections are prepared are numbered consecutively in the order in which they are cut, and are entered in books kept for the purpose. When they have been described and named they are again entered in two distinct catalogues, one of which is arranged according to the sheets of the one-inch map, and the other according to petrographical types. It will thus be seen that every sliced specimen is entered four times, and that every specimen sent up for examination, whether sliced or not, can at once be found.

On the general question of metamorphism much important detail has been accumulated. The fact that the central and southern Highlands of Scotland are largely composed of highly crystalline rocks of sedimentary origin has long been known. Petrographical work has tended to render the correctness of this view more and more certain. Thus fine-grained quartzo-felspathic rocks, which show no decided indications of clastic origin, have been found to be traversed by narrow dark bands in which minute crystals of zircon, rutile, and ilmenite abound. Similar bands occur in loose sandy deposits of much later geological age, so that the doubtful rock may be recognised as really a sandstone consolidated by the secondary enlargement of the quartz, and possibly also of the felspar grains. The detailed microscopic work of the department has also thrown much light on the nature of the processes by which the present mineralogical and structural characters of the Highland rocks have been produced.

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE results of an inquiry into the position taken by Universities in different parts of the world as regards the admission of women, are given in the *Revue Scientifique*. It appears that the French Faculties opened their doors to women for the first time in 1863. None of the German Universities yet admit women either to lectures or examinations. There will be a difficulty, however, in resisting for long the force of opinion in favour of the admission of women to courses of study, and especially to medical classes. A petition for the removal of the present restrictions was presented to the Reichstag not long ago, containing more than 50,000 signatures of women. In Austria-Hungary and Spain the laws are against the access of women to higher education. Women possess a special school of medicine in Russia, in spite of their exclusion from the Universities. In Belgium, women are admitted to the courses in all the Faculties, and are eligible for all diplomas. They may also follow the medical profession, or become dispensing chemists. Holland has a large number of women students in its Universities, but Switzerland heads the list in this respect. During the summer semester of 1892, no less than 541 women students were studying in Swiss Universities. In Italy women are admitted to all the Faculties, and are at liberty to exercise all professions except the legal. Among the professors in Bologna University, a lady occupies the chair of histology in the Faculty of Medicine. The Universities of Jasi and Bucharest, in Roumania, are open to women, as are also those of Denmark, Sweden, Norway, and Iceland. Higher education is available for women in most parts of the United States. The result of this is that America has about 3500 women following various branches of the medical profession, 70 have been appointed physicians in hospitals, and nearly 100 are professors in schools of medicine.

THE Council of the Association of Technical Institutions have sent a letter to Mr. Gladstone with reference to the Royal Commission on Secondary Education, the appointment of which was recently announced. The signatories point out that, as the education given in the institutions represented by them is a necessary and important part of the general secondary education of the country, it is of great importance that the Royal Commission should be fully informed as to the nature of the work that is being done, as to the best means of improving and extending this work, and so enabling the institutions most efficiently to take their share in the work of national education. They therefore urge that the Royal Commission should be expressly empowered to deal with technical education, and in order that it might be able to do so effectually, that there should be among the Royal Commissioners an adequate number of gentlemen of experience as administrators and teachers of technical institutions.

THE Italian Government has decided to suppress six small universities—those of Messina, Catania, Modena, Parma, Sassari, and Siena—the academic population of which is from 100 to 400.

SCIENTIFIC SERIALS.

Bulletin of the New York Mathematical Society, vol. iii. No. 5.—Prof. Klein's recent visit to Chicago was taken advantage of by American mathematicians. One of the most interesting results was the publication of twelve lectures on mathematics, with the title of "The Evanston Colloquium." An abstract of the contents of this work, by H. S. White, occupies pp. 119–122 of the present number. L. E. Dickson contributes a note on the number of inscriptible regular polygons (pp. 123–125). E. M. Blake (pp. 125–127) writes upon the "Bibliography of Mathematical Dissertations." His remarks are based upon two recently issued works, viz. "Catalogues des Thèses de Sciences soutenues en France de 1810 à 1890 inclusivement, par A. Marie (1892)," and "Verzeichnis der Seit 1850 an den Deutschen Universitäten erschienenen Doctor-Dissertation en und Habilitationsschriften aus der reinen und Augewandten Mathematik" (München, 1892). The Paris dissertations are 701 in number, and the departments furnish 172 more. The German work gives references to 939 dissertations. Both books supply a want which has long been felt, for most of these dissertations appear unannounced at irregular intervals, and are with difficulty

run to earth. The remaining article is on the teaching of mathematics in the secondary schools (pp. 127–130), and consists of an extract from the report rendered to the National Educational Society, December 1893, by the Committee on Secondary School Studies.

Meteorologische Zeitschrift, February.—The results of the Swedish International Polar Expedition at Cape Thorsden, Spitzbergen, 1882–83, by Dr. J. Hann. The meteorological results, which have only recently been published, show that the winter temperature is relatively very mild compared with that observed at all the other Polar stations north of 70° N. latitude. In the year commencing September 1882, and ending August 1883, Cape Thorsden, latitude 78° 28′, had the smallest extreme cold, with the exception of Jan Mayen, latitude 71°, while the summer was very cool. The lowest mean monthly temperature was −1°·3 in December, and the absolute minimum −31°·9 in January; the highest mean monthly temperature was 40°·3, and the absolute maximum 56°·5, both in August. The yearly rainfall (including snow), was 7·4 inches; no real hail fell during the year. The daily range of the barometer shows a double period, as in lower latitudes, but the maxima and minima occur at different hours; the day maximum occurs about 1h. p.m., and the minimum about 6h. a.m., and there is a second maximum from 10h. p.m. to midnight, and a second minimum about 6h. p.m. In summer the amplitudes are much smaller than in winter; the day maximum then occurs from about noon to 1h. p.m., and the afternoon minimum about 6h. p.m. The prevalent wind directions are east and west; in summer the south-west wind is most frequent, and in winter north-west and east. The daily range of wind velocity is very marked in summer, the maximum occurring about 1h. p.m., and the minimum about 1h. a.m.; while the reverse obtains in winter, but with less regularity.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, March 1.—"Terrestrial Refraction in the Western Himalayan Mountains." By General J. T. Walker, C.B., F.R.S.

In the operations of the great Trigonometrical Survey of India it is customary to determine the coefficient of refraction by reciprocal vertical observations between contiguous stations on the sides of all the principal triangles, and also as many as possible of the secondary triangles.

The values of the coefficient thus obtained for the operations in the Western Himalayas—between the meridians of 73° and 80° east of Greenwich—have been grouped together for comparison in successive ranges of 2000 feet of altitude between the elevations of 5000 and 21,000 feet above the sea-level. The operations happen naturally to have been divided into two sections; for the regions lying between the great snowy ranges on the southern face of the Himalayas and the plains of India were first completed, and some time subsequently the still higher regions to the north, extending up to the Karakoram and Kuenlun Ranges, which look down on the plains of Turkestan. The first portion appertains to what is called the N.W. Himalyan Series, the second to what is called the Kashmir Triangulation. Thus the values of the coefficients of refraction were obtained separately for each section, and the results show that at each range of altitude the coefficient of refraction was greater in the Southern than in the Northern Section; also that from the height of 13,000 feet upwards the coefficient decreased in magnitude, as it theoretically should do, in the Northern Triangulation, but, on the other hand, in the Southern it increased until it became twice as great as in the Northern. These differences of behaviour in the two regions are very curious and difficult to account for. They point to some difference in the atmospheric conditions to the north and south of the outer Himalayan Range, and this may possibly arise from the circumstance that the atmosphere to the south is more heavily laden with moisture than the atmosphere to the north; for the great southern range is the first to receive the clouds which come up from the Indian Ocean, and which are the chief source of Himalayan moisture; these clouds are mostly condensed into rain on the southern face of the range, and thus only a comparatively small portion of their contents is carried on beyond into the more northerly regions. Whatever the cause, the fact is very remarkable that the coefficient of refraction has a minimum value at an altitude of 20,000 feet on the north side of the Himalayan Ranges, and a maximum value at the same altitude on the south side.

"On a Spherical Vortex." By Dr. J. M. Hill, Professor of Mathematics at University College, London.

The nature of the irrotational motion of an infinite mass of frictionless fluid, in which a solid sphere is moving, is well known. The object of this investigation is to show that continuous motion throughout space is possible if the solid sphere be replaced by a spherical mass of rotationally moving fluid. This spherical mass is the spherical vortex of the investigation. Its centre moves with uniform velocity along a straight line, which may be called the axis of the vortex. The surfaces inside the vortex which contain the same particles of fluid throughout the motion are ring-shaped surfaces of revolution about the axis, but are not anchor-rings. The molecular rotation at any point of the vortex is proportional to the distance of the point from the axis. The cyclic constant of the spherical vortex is equal to five times the product of the radius of the sphere and the uniform velocity with which the vortex moves along its axis.

Dr. E. L. Mellus made a preliminary report of the results of experimental investigation of the central nervous system of the monkey (*Macacus sinicus*) at the pathological laboratory of University College. Small portions of the cortex cerebri were removed from the left hemisphere, amounting in each case to about 16 sq. mm. At the end of three weeks the animals were killed, and the resulting degeneration traced by Marchi's method. Two foci of representation were selected for excision: the focus for the movements of the hallux, and the focus for the movements of the thumb. In the former, degeneration had taken place extensively throughout the pyramid of the left side down to the decussation in the cervical region, where the degenerated fibres were seen to divide, the greater portion, about two-thirds, crossing over to the opposite (right) lateral column, the remainder passing through the grey matter to the lateral column of the left side. This degeneration was maintained throughout the entire cord to the lower lumbar region. In the case of the removal of the thumb centre similar degeneration was observed, though the number of degenerate fibres was less than in the former. At the decussation the tract also divided, though the proportion of fibres going to the left lateral tract was much less than in the case of the hallux, and there was no degeneration of the cord below the level of the second dorsal nerve.

Mathematical Society, March 8.—Mr. A. B. Kempe, F.R.S., President, in the chair.—The following papers were read:—Groups of points on curves, by Mr. F. S. Macaulay. In the earlier part of the paper a proof is given that any n^{ic} through all the points of intersection of two given curves C_l, C_m of orders l and m is necessarily of the form

$$S_n \equiv C_l S_{n-l} + C_m S_{n-m} = 0$$

but the chief part of the paper is an investigation of the amount of independence of a group of points on a given curve which are residual to the partial intersection of the given curve by another curve of any order. The question may be expressed thus:—"If three curves C_l, C_m, $\underline{C_n}$ $(l \not> m \not> n)$ have N points common (N being not less than $\frac{1}{2}l.\overline{l+3}$), what is the amount of independence of the remaining points common to C , C_n (and those common to C_n, C_l) for curves of any order passing through them, and what is the number of absolute relations that connect either of the above groups of points among themselves?" The method of investigation is geometrical, *i.e.* it does not depend on the solution of any equations or on the investigation of the properties of a curve from its equations.—On a simple contrivance for compounding elliptic motions, by Mr. G. H. Bryan. The author exhibited a number of "pendulum curves" drawn with a very simple arrangement based on the principle of a pendulum curve-tracer that he saw exhibited at the British Association meeting at Nottingham. The paper to be drawn on is placed on a heavily weighted board suspended from two points overhead by strings attached to its four corners in such a way that it can swing in any direction without twisting round. From the under-side of the board is suspended a weight, thus giving two periods of oscillation. The pen is attached to a triangular framework, hinged to fixed supports, and carefully counterpoised. The pen thus rests gently on the paper, which moves about underneath. The author uses a kind of "reservoir pen,"

formed by bending down the nib of an unfinished and unhardened barrel pen, so as to rest against the under-side of the nib of an ordinary, fine grey steel pen, the space between the two nibs holding sufficient ink to draw the finest and most elaborate patterns without the ink running into blots. The most beautiful curves are those obtained by compounding two circular motions whose periods are nearly but not quite in the proportion of, say, two to one. To do this, however, a certain amount of skill is requisite in starting the machine.—On the buckling and wrinkling of plating supported on a framework under the influence of oblique stresses, by Mr. G. H. Bryan. The present investigation is chiefly interesting as forming an addition to the small class of soluble problems in which the question of stability arises in connection with the theory of elasticity. In a previous communication the author discussed the kind of buckling which arises when a rectangular plate has to support thrusts in its own plane, applied perpendicularly to its edges, and of sufficient magnitude to render the plane form unstable. The problem now considered is that of a sheet of plating of indefinite extent supported on equidistant parallel ribs, or on a rectangular framework formed by two such sets of ribs crossing each other, and which is compressed by thrusts applied in any direction not necessarily perpendicular or parallel to the ribs. Let the plating be supported on parallel ribs at distances b apart, and let it be compressed by a thrust P (per unit length measured in the plane of the plate) in a direction making an angle α with the ribs. Then using C to denote the cylindrical rigidity of the surface, the conditions of instability may be summed up as follows:—

(1) If $\alpha < 30°$, the plane form will become unstable when

$$P > \frac{4\pi^2 C}{b^2}$$

and wrinkles will then appear on the surface. These wrinkles will run in directions perpendicular to the direction of P (*i.e.* at an angle $90° + \alpha$ with the ribs, and will consist of alternate elevations and depressions, the lines separating which will be at distances b apart. In other words, the wrinkles with the ribs will divide the plate into rhombi, in which the displacements will be alternately to one side and to the other of the plane form.

(2) If $\alpha < 30°$, the same form will become unstable if

$$P > \frac{\pi^2 C}{b^2 \sin^2 \alpha}$$

and the plating will then buckle into simple corrugations running parallel to the ribs, the displaced form of the plate being a cylindrical surface, of which the section perpendicular to the ribs is a curve of sines. The corresponding results are also worked out for a plate supported on a rectangular framework. A simple rough-and-ready illustration of these results is afforded when a sheet of paper is thrown into wrinkles.—On the motion of paired vortices with a common axis, by Mr. A. E. H. Love. One of the difficulties of the application of the vortex atom theory to problems of radiation lies in the great frequency of all the modes of oscillation of a single ring. The periods are all of the order of magnitude of the time taken by the ring to move over a distance equal to its diameter, and theories of radiation appear to require the existence of very much longer periods. It is not unlikely that such periods may depend on the relative motions of the constituents of a molecule or molecular group consisting of several ring atoms. The simplest case is that of two rings on the same axis passing through each other alternately. The period of this motion when the rings have very different diameters would be very difficult to determine, but it is probable that its order of magnitude can be obtained by considering the corresponding problem in two dimensions. A pair of cylindrical vortices of equal and opposite strengths moves perpendicularly to the plane joining the vortices, and thus behaves like a single ring. Two such pairs with their planes parallel can pass alternately through each other. The case considered is that in which all the vortices are of equal strength (disregarding sign). It is proved that the relative path is always such that, at some instant, the four vortices are in a straight line at right angles to the axis of symmetry, or one pair is passing through the other. It is proved that the relative motion is periodic provided the ratio of the breadth of the wider to that of the more contracted pair, at the instant when one is passing through the other, is less than $3 + 2\sqrt{2}$. The curves described by either vortex of one pair relative to the homologous vortex of the other pair are found. These curves are very nearly ellipses, with their major axes parallel to the axis of symmetry, and they tend to become very elongated when the condition for the motion to be non-periodic is nearly fulfilled, but they are very nearly circular when the ratio of the breadths of the pairs at the instant when one is passing through the other is as great as 2. This result seems to have some bearing on the theoretical conditions of chemical combination. The length of the period is proved to be $\frac{4\pi c^2}{m}\frac{(1+\kappa')^2}{\kappa'(1-\kappa')}(E - K\kappa')$, where m is the strength of one of the vortices, $2c$ the mean breadth of the two pairs, E and K are complete elliptic integrals of the second and first kinds of a certain modulus κ, and κ' is the complementary modulus. The modulus κ' is $(6Rr - R^2 - r^2)/(R + r)^2$, where $2R$ and $2r$ are the breadths of the pairs at the instant when one is passing through the other. The expression for the period is discussed in particular cases, and it is shown that if the order of magnitude of the corresponding period for two vortex rings is the same as that for two vortex pairs, it is in fact long compared with any period of oscillation of a single ring.—On the existence of a root of a rational integral equation, by Prof. Elliott, F.R.S.

DUBLIN.

Royal Dublin Society, February 21.—Prof. Arthur A. Rambaut, Astronomer Royal for Ireland, in the chair.—Mr. W. E. Adeney read a paper on the reduction of manganese peroxide in sewage. The author stated that freshly precipitated peroxide of manganese, when mixed with sewage matters, and allowed to air-dry slowly, becomes gradually decomposed into manganous carbonate. He gave an analysis of some manganous carbonate, formed in this way, showing that the reduction of the peroxide is complete when it is exposed in small heaps to the air in the course of about three months.—A paper on eozoonal structure of the ejected blocks of Monte Somma, by Dr. J. W. Gregory and Prof. H. J. Johnston-Lavis, was communicated to the Society by Prof. G. A. J. Cole. The authors show that the limestone-blocks of Mesozoic age in Monte Somma have frequently become metamorphosed into crystalline masses consisting of alternating bands of calcite and various silicates. The authors regard the silica, magnesia, &c. as derived from the igneous rock by chemical interpenetration and interaction. Where the silicate, as often happens, is olivine (montecellite), or a pyroxene, a complete simulation of the structure of *Eozoon canadense* is produced. The layers of silicates occur parallel to the surfaces of any igneous vein that may have intruded into the limestone, and they become closer to one another in the areas farther removed from contact. The "proper wall," the "stolons," and in places the "canal system" of eozoon are recognisable under the microscope; and the authors adduce evidence to show that the typical eozoonal limestone of Canada may have arisen similarly as a product of contact metamorphism.—Prof. Cole then presented a paper upon derived crystals in basaltic andesite of Glasdrumman Port, co. Down. The author described a large composite dyke showing at this point a band of andesite on each side of it, from 4 to 17 feet wide, and a more recent dyke of eurite in the centre, 36 feet across. The eurite includes numerous blocks of andesite, and sends off veins into it; but the pyroxene and glass of the latter rock have become remelted at the contact, a delicate interpenetration of the two magmas has occurred, and the porphyritic crystals of quartz and pink felspar from the eurite are found completely surrounded by the dark andesite. Thus a pre-existing rock comes to include crystals derived from one that has subsequently invaded it, and hand specimens, apart from study in the field, would be of a most misleading character.—Sir Howard Grubb read a paper on a new form of equatorial mounting for monster reflecting telescopes, observing that as our neighbours in France intend constructing a 3-metre reflector for the Paris Exhibition of 1900, this may not be an inappropriate time to discuss the question of mounting reflecting telescopes of monster sizes, *i.e.* of 8 or 10 feet diameter. The problem to be solved is that of mounting, on an equatorial movement, a telescope of, say, 80 or 100 tons weight, so perfectly equipoised and relieved of friction that it can be conveniently manipulated and carried by clock-work, or some motive power, to follow a celestial object with such accuracy that it will not at any moment vary from its correct position by a quantity equal to the apparent motion of that object in a space of one-tenth or one-twentieth part of a second. To effect this the author proposes to develop further a

system already adopted by Dr. Common, viz. the flotation of the polar axis of the telescope. This is done by making a tube for the Newtonian reflecting telescope (which is necessarily closed at the lower end) of such a weight, and with its weight so distributed that it will not only float in water at a certain point (preferably near the upper end), but will be in a state of equilibrium when placed at any position down to a certain angle, say to within 20° of the horizon, the angle depending on the exact outside form of the tube. With a pair of trunnions attached at the water-line, an 80-ton telescope could be mounted and carried by an equatorial without throwing any weight whatever on that equatorial, the force necessary to drive the instrument being dependent only on the friction to be overcome in carrying the tube at an exceedingly slow rate through the water.

PARIS.

Academy of Sciences, March 12.—M. Lœwy in the chair.—Observations of the new planet BB (Charlois), made at the Paris Observatory, by MM. O. Callandreau and G. Bigourdan.—Preparation and properties of boron carbide, by M. Henri Moissan. Several methods are given for the preparation of this compound at the high temperatures of the electric arc. Clearly-defined crystals of CB_6 are obtained by heating the requisite quantities of carbon and boron with about twice their weight of copper in the electric furnace for six or seven minutes. After solution of the copper and extraction of a little graphite, the residue has a density of 2·51, and is hard enough to polish diamond. The properties of this compound are given at length.—On the reproductive organs of *Ancylus fluviatilis*, by M. de Lacaze-Duthiers.—On the internal pressure of fluids and the form of the function $\phi(pvt) = O$, by M. E. H. Amagat. The author takes the general form $(p + \pi)(v - a) = RT$, hence develops the formula $\left(p + T\frac{dp}{dt} - p\right)(v - a) = RT$, in which $\frac{dp}{dt}(v - a) = R$, whence the values of a for a series of volumes are calculated. These values may be represented by the expression $a_v = \alpha + B(v - \alpha)^n$ where $B = 0·0077$, $n = \frac{1}{2}$, and $\alpha = 0·0004$. But, from the variation of π (the internal pressure) with the volume, we have $\pi = A\frac{v - \epsilon}{v^m}$; for hydrogen $A = 0·000506$, $m = 3$, and $\epsilon = 0·002111$. With these values of the arbitrary constants the formula

$$\left(p + A\frac{v - \epsilon}{v^m}\right)(v - [\alpha + B(v - \alpha)^n]) = RT$$

gives for hydrogen values for the pressure calculated from the volume agreeing well with the actual pressures from 100 to 2800 atmospheres. The calculated interior pressure for unit volume at zero temperature and normal pressure is 0·000875 atmos. Kelvin and Joule's experiments make the value 0·0008 atmos.—Magnetic observations in Madagascar in 1892, by P. E. Colin.—On the presence of a polymorphous microbe in syphilis, by Dr. Golasz. The author gives evidence of the existence in the blood of syphilitic patients of a polymorphous bacillus belonging to a species nearly related to Leptothrix and Cladothrix, and hence similar to the species found in cases of tuberculosis, leprosy, and glanders.—On the triangle of sequences. An abstract of a memoir by M. Désiré André.—Observations of the new planets AX (Wolf, March 1) and AZ (Courty, March 5) made at Lyons Observatory, by M. G. Le Cadet.—Observation of the planet 1894 AZ, made with the great equatorial of the Bordeaux Observatory, by M. L. Picart.—Observations of planets, made at the Toulouse Observatory (Brunner equatorial), by M. F. Rossard.—Solar phenomena observed during the third and fourth quarters of 1893, at the observatory of the Roman College. A letter from M. P. Tacchini.—On the capillary depression of the barometer, by M. C. Maltézos. A mathematical investigation resulting in the expression of the opinion that the practical comparison method must still be relied on for correcting barometric heights for capillarity.—Achromatism and chromatism of interference fringes, by M. J. Macé de Lépinay.—Use of electricity for following the phases of certain chemical reactions, by M. Jules Garnier.—A contribution to the study of ferments, by MM. P. Hautefeuille and A. Perrey.—On the spark spectra of some minerals, by M. A. de Gramont. The mineral sulphides, selenides, and tellurides, and native gold, silver, copper, bismuth, arsenic, and antimony have been studied.—Influence of time on the absorption of carbon monoxide by the blood, by M. N. Gréhant.—On the prostatic utriculus and the vasa deferentia in the cetaceæ, by MM. H. Beauregard and R. Boulart.—On composite ascidians of the genus *Distaplia*, by M. Caullery.—On ears of maize attacked by *Alucite des cereales* in Central France, by M. A. Laboulbène.—Influence of potassium salts on nitrification, by MM. J. Dumont and J. Crochetelle.—On the fertility of the giant *Persicaire* (*Polygonum sachalinense*), by M. Ch. Baltet.—Physiological researches on fungi, by M. Pierre Lesage.—On the fossil *Cedroxylon varolense*. A note by MM. B. Renault and A. Roche.—On the variation of the composition of the water of lakes with the depth and according to the seasons, by M. A. Delebecque.—On the temperature of caverns, by M. E. A. Martel.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Statesman's Year-Book, 1894 (Macmillan).—A Handbook of Gold-Milling: H. Louis (Macmillan).—The Handbook of Jamaica for 1894 (Stanford).—Ueber die Spectren der Elemente: H. Kayser and C. Runge (Berlin, Reimer).—Deutsche Ueberseeische Meteorologische Beobachtungen, Heft vi. (Berlin).—Construction et Resistance des Machines a Vapeur: Alheilig (Paris, Gauthier-Villars).—Machines Frigorifiques a Air: R. E. de Marchena (Paris, Gauthier-Villars).—Popular Lectures and Addresses: Lord Kelvin, Vol. 2, Geology and General Physics (Macmillan).—A Treatise on Hydrostatics: Prof. A. G. Greenhill (Macmillan).—Methods of Pathological Histology: Prof. C. von Kahlden, translated and edited by Dr. H. M. Fletcher (Macmillan).

PAMPHLETS.—Return of Mineral Production in India for 1892 (Simla).—River Temperature, Part 1: H. B. Guppy.—The Aerial Oxidation of Terpenes and Essential Oils: C. T. Kingzett.—Quelques Conclusions et Applications de l'Anthropologie (Paris, Masson).

SERIALS.—Bulletin of the Natural History Society of New Brunswick, No. 11 (St. John, N.B.).—Journal of the Chemical Society, March (Gurney and Jackson). Insect Life. Vol. 6, No. 3 (Washington).—Rendiconto dell' Accademia delle Scienze Fisiche e Matematiche, serie 2ª, Vol. 8, fasc. 1°, e 2° (Napoli).—Economic Journal, March (Macmillan).—Journal of the Institution of Electrical Engineers, No. 109, Vol. xxiii. (Spon).—American Naturalist, March (Philadelphia).—Royal Natural History, Vol. 1, Part 5 (Warne).—Proceedings of the Indiana Academy of Sciences, 1892 (Brookville, Ind.).

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